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Pipe-Molding Machine and Continuous Pipe Foundry at Coshocton, Ohio.

Continuous molding and casting is not the practice in ordinary foundry work. As many molds are prepared as the available floor space or the supply of suitable flasks will permit, and then the making of molds is discontinued while all the prepared molds are poured. The first molds completed stand idle until all are ready. Similarly, the last molds poured have been standing idle during the pouring of the others; and the equipment for molding and casting is all idle while the flasks are being emptied, the sand retempered and mixed and the floor cleared for molding again. With many classes of work it would be difficult, if not wholly impracticable, to put into use a system of continuous molding in which the various processes were being performed continuously and simultaneously. It is plain, however, that where the character of the work permits, equipment, floor space and labor can be employed to better advantage by introducing some plan whereby each flask can pass without interruption or delay through the whole series of operations involved in preparing, pouring and emptying the molds.

The manufacture of cast-iron pipe offers special opportunities for the introduction of a continuous system of molding and casting. The large number and tonnage of exact duplicates to be cast make continuous work particularly desirable, and the simple shape of the pattern and core makes it comparatively easy to arrange a continuous system for pipe casting. Circular-floor or turntable systems have been tried with some success, but in general are open to the objection that a delay or accident at any one flask may hold up the entire plant. The Herbert system, recently installed at the new plant of James B. Clow & Sons, at Coschocton, Ohio, does away with this difficulty entirely, and at the same time introduces improved methods of molding, drying and coring.

The most important single feature of the Herbert system is the molding machine, in which the pattern itself is made to ram or press the sand into shape. The flask is secured in a vertical position above the machine and the sand is shoveled in. The pattern is then forced up through the sand from below by a hydraulic ram, thus forming the mold. With the ordinary method of molding, the flask must be rammed with the bell or socket end of the pipe up. Then, in order to avoid pouring the flask in this inferior position, it must be picked up and turned end for end. Pipe is often cast bell end up in this country, for this very reason; but the other way is better because it permits a shrinkage head to be cast on the pipe which can later be cut off, removing with it the weak iron naturally formed at the upper end. In pipe cast with the bell end up, the hub, or bell, has the weakest iron in the pipe, whereas it should be the strongest to resist the stress put upon it in calking the joints when the pipe is laid. The Herbert pipe molding machine not only rams the mold with the bell end down, so that it can readily be poured in this position, but rams it much more evenly than can possibly be done by the ordinary method.

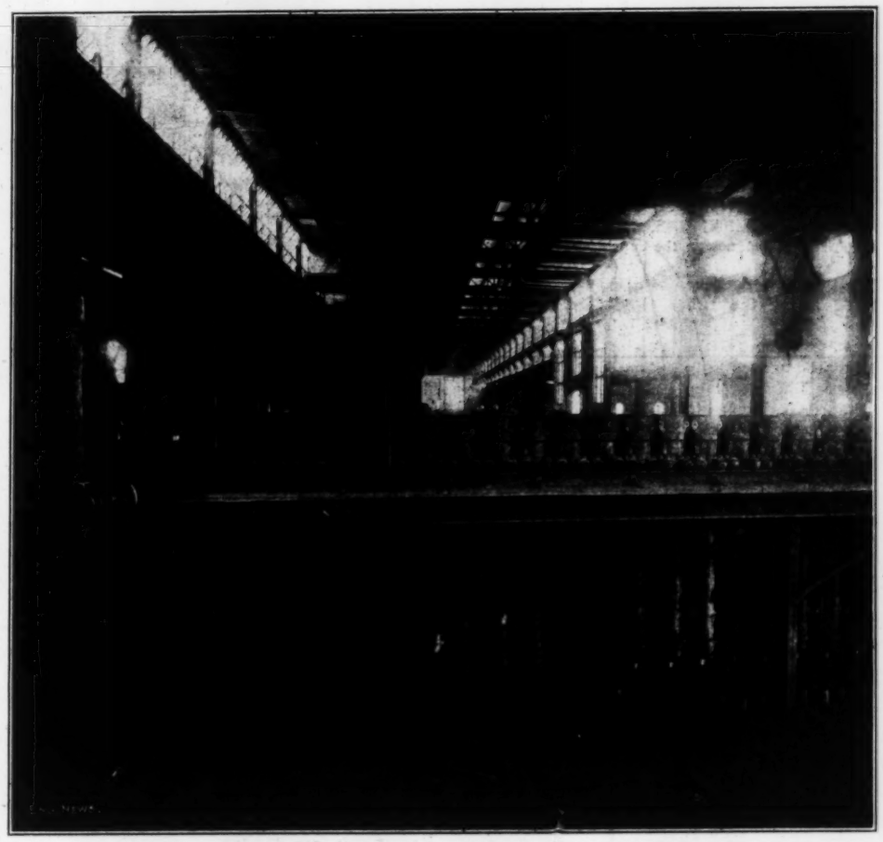


FIG. 1. CONTINUOUS PIPE-CASTING PIT AT COSHOCTON, OHIO: VIEW FROM DRYING-TRACK SIDE.

(Note the producer-gas burners under each flask and the transfer car at the left end of the pit.)

The whole process of molding and casting in the Herbert system is performed with the flasks standing erect in a pit. The pit is made large enough to contain four rows of 25 or 30 flasks each and is deep enough so that the upper ends of the flasks protrude only 2 or 3 ft. above the main floor above, from which most of the work is done. The flasks are held upright in parallel rows by rails running lengthwise of the pit, which rails are supported on a suitable framework erected between the rows of flasks. The rails are on the level of the main floor; and the flasks are hung upon them each on a separate truck (see Fig. 1). The entire train of flasks on any one line of rails can be moved along the track at once by means of hydraulic rams mounted at the end of the line.

The molding machine is set up vertically in a sub-pit at one end of the main pit (see Fig. 3) so that its upper end is at a convenient height to receive the lower ends of the flask as they are pushed toward it along the rails above. The molding machine is installed in duplicate, that is with two cylinders side by side, so that two flasks can be rammed at the same time. To correspond, there are two tracks above, along which two rows of flasks are moved toward the machine. There are two other tracks, parallel to the first pair, to which the flasks discharged

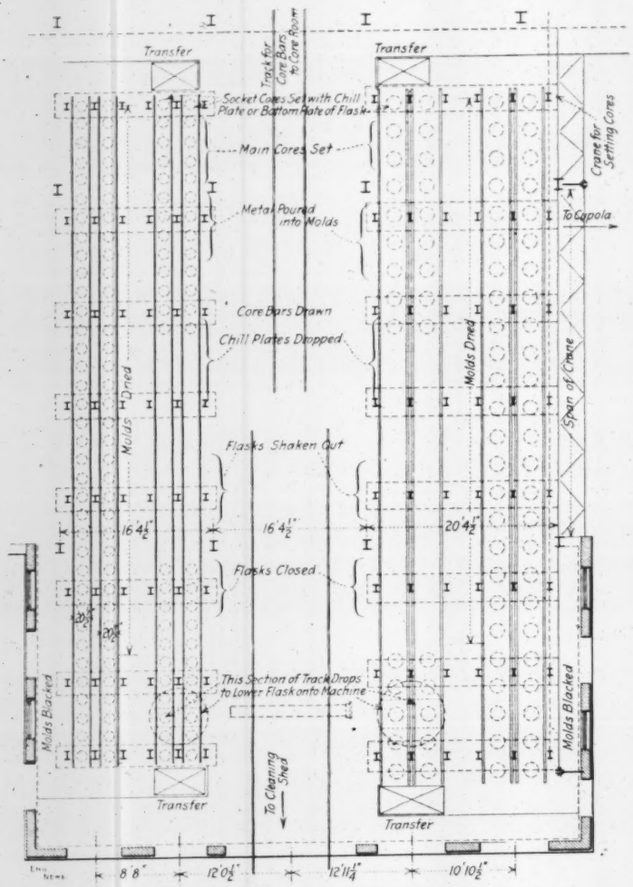


FIG. 2. PLAN VIEW OF THE COSHOCTON PIPE FOUNDRY, SHOWING SEQUENCE OF OPERATIONS.

(The pit for the larger sizes of pipe is placed nearer the cupola at the right.)

from the molding machine are transferred. The flasks move in opposite directions on the two pairs of tracks.

After passing over the machine, where the mold is formed, each pair of flasks moves onto a transfer car just beyond the end of the track or runway. This car carries the flasks across in line with the adjacent pair of tracks, on which they are started back toward the opposite end of the runway. At the commencement of this return trip the molds are blacked, after which they pass over burners fed by producer gas whereby the blacking and molds are thoroughly dried. Upon reaching the further end of the runway, each pair of flasks passes again onto a transfer car, which takes them across to the first pair of tracks. Here the cores are inserted and the flasks pushed further along ready to be poured. After pouring, the core bars are drawn, the flasks opened and the newly cast pipe lifted out. In removing the pipe the sand is shaken out of the flask and falls through a grating to the mixing and tempering plant in the pit below, whence it is returned by a bucket elevator to the molding machine ready to be used over again.

The inventor of the machine and the continuous system is Mr. Fred. Herbert, of Birtley, England.* The machine has been in use separately in England for about four years, and the continuous process has been in use for about two years at the plant of Cochrane & Co., Ltd., Middlesbrough, England. It was at this plant that the Herbert system was examined by Mr. C. M. Aland (now General Superintendent of the Coshocton plant), who had been sent to England and Germany by the Clow firm to investigate methods of continuous pipe casting. The Clow plant at Coshocton has been in use for some months manufacturing 4 and 6-in. pipe. Both of these sizes are made in the same flasks, using, of course, different patterns and cores. The same pit is to be used also for 3-in. pipe, but a different set of flasks—of smaller diameter—will be used for this size. A duplicate installation is now nearing completion, which will turn out 8, 10 and 12-in. pipe.

The two installations occupy what is really a single pit about 90 × 50 ft. in plan and 12½ ft. deep. They are separated, however, by a platform at the main floor level (12½ ft. above the bottom of the pit). This platform is about 16 ft. wide and extends the whole length of the pits. The tracks for the cars on which the core bars are returned to the core room are laid on this central floor, or platform, which supports also the skids along which the pipes cast are rolled to the cleaning shed. The accompanying plan (Fig. 2) gives an idea of the general arrangement. In each pit, the pair of tracks next the central floor is used for coring, pouring, shaking out and molding while the outer pair of tracks is used for drying the molds. Between the two pairs of tracks is a 3-ft. walk or gangway. This is shown in use by the man pouring the molds in Fig. 9. The length of each track from end to end of the pit is 72 ft. and the drying tracks (two in each pit) are kept full of flasks. In the 3 to 6-in. pit, there are 36 flasks on each drying track. The other two tracks have each only 24 flasks, so that the total number of (single) flasks in this pit is 120. The capacity of the pit is 30 pipes per hour, or 600 pipes per day of two ten-hour shifts.

*Present address, 853 South Seventh St., Coshocton, Ohio.

The Molding Machine and Flask.

The molding machine is perhaps the most essential feature of the Herbert system, since it permits the flasks to be readily rammed in the position in which they are to be poured, and moreover permits the mold to be completed in about 2½ minutes. The form of flask used is shown in Fig. 7. It is made of cast iron divided in half longitudinally. The two halves are held together by dowels and cotter keys. The length of the flask is about 13 ft. The flasks for 6-in. pipe have an inside diameter of 9¼ ins., and a wall thickness of about ½-in. These same flasks are used also for 4-in. pipe. Each flask is suspended vertically from the rails of the runway between the two axles of its trucks, which are attached at a point about 2½ ft. from the flask's upper end. On the ends of the axles are flanged wheels, which roll on the rails of the runway. The track gage is 20½ ins. Each half of the flask is hung separately on two small rollers arranged to roll transversely on the axles of the main wheels. These rollers are brought into play when the two halves of the flask are separated for shaking out. About [illegible] below the point at which the trucks are attached, the flask has a pair of buffers extending parallel to the rails of the runway fore and aft. These buffers serve to keep the flasks at the proper distance apart (2 ft. c. to c. for flasks for 6-in. pipe), and transmit from the flask the push of the hydraulic ram which moves them along the runway. A second pair of buffers near the lower end of the flask, which can be plainly seen in Fig. 4, serves to maintain the spacing at the lower ends.

Immediately above the molding machine a section of the runway track long enough to accommodate one flask is arranged to be lowered a few inches and raised to position again by means of hydraulic plungers. The empty flask is rolled onto this drop-section of the track and lowered into position at the upper end of the molding machine, where it is secured by [illegible] pushed into slots in the four dowel-pins projecting from the top of the machine. Fig. 5 shows a flask attached to the machine in this way. A light metal tube (16-gage), known as a measuring tube, is then lowered into the flask by a man on the platform above. A measuring tube lowered part way into a flask is shown in

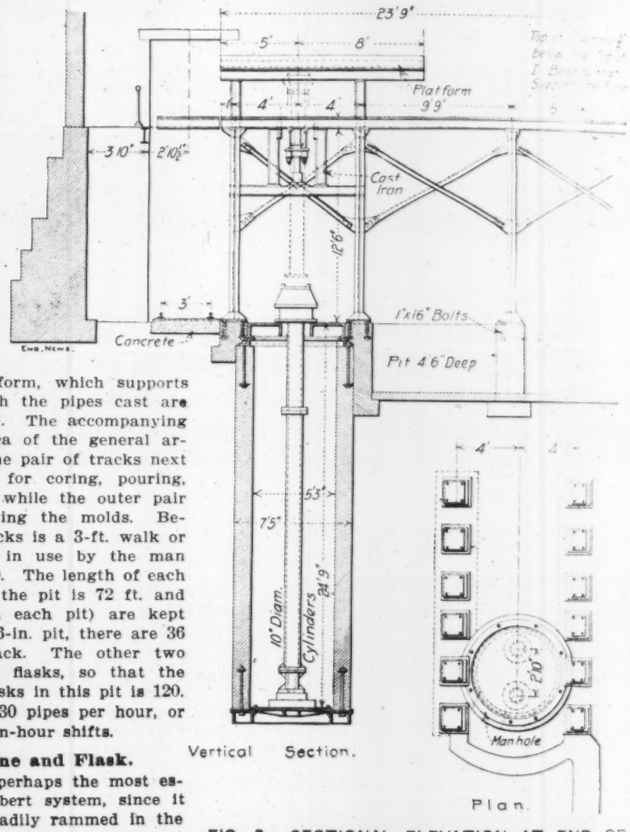
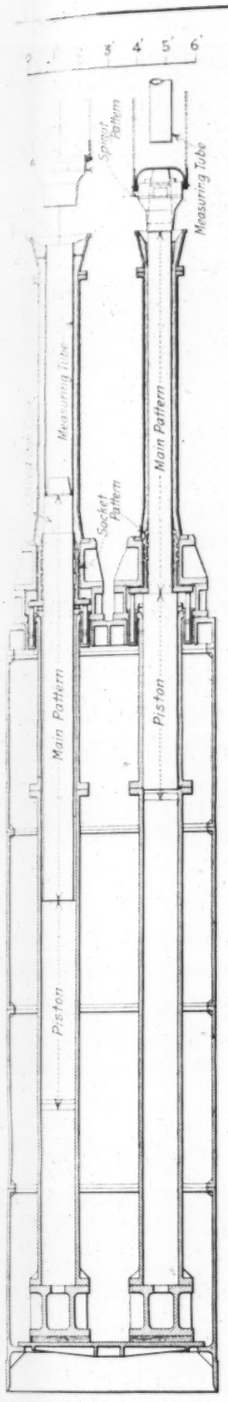


FIG. 3. SECTIONAL ELEVATION AT END OF PIT, SHOWING LOCATION OF PIPE-MOLDING MACHINE.

Fig. 6. The two tubes for the two cylinders of the machine are hung side by side on ropes passing over pulleys and are counterbalanced so that they can be easily raised or lowered to the proper position. In Fig. 6 the spider for centering the tube in the flask can be seen hung askew on the top of the nearer tube. The lower end of the tube carries a hollow chilled-iron cone about 18 ins. long, which fits over the conical end of the pattern shown projecting from the nearer machine in Fig. 5.

When the measuring tube has been put in place, sand is shoveled into the flask around



Vertical Section.

Sectional Plan.

Fig. 4. The Herbert Pipe-Molding Machine: Sectional View With Flasks in Position for Molding.

(Left-hand flask, ready for ramming. Right-hand flask, mold completed.)

the outside of the tube. The sand is then leveled off with a special strike at the upper end to fix definitely the quantity of sand in the flask. The pattern itself consists simply of a cast-iron cylinder, having the proper diameter for the pipe to be cast. For 6-in. pipe the pattern diameter is 7⅛ ins. The outside diameter of the measuring tube is somewhat smaller than that of the pattern (6½ ins. in diameter for 6-in. pipe), so that, when the pattern is forced up through the mold by the hydraulic ram of the molding machine pushing the chilled-iron cone ahead of it, the sand is compressed to the desired consistency. Two or more measuring tubes of different size are kept on hand for each diameter of pipe. If it is found that the mold is being rammed too hard, due to possible variations in the quality of the sand, a tube of slightly larger diameter can be used. With the larger tube there will be less room for sand between it and the flask, and thus with less sand in the flask the mold will not be rammed quite as hard.

It was found, that when the maximum or base diameter of the cone was made the same as that of the pattern, the sand was not sufficiently compressed. For when the main pattern was drawn downward out of the mold, the sand would expand apparently by its own elasticity so that the bore of the mold would be left slightly smaller than the pattern. This difficulty was satisfactorily adjusted by making the base of the cone, in the case of 6-in. pipe, 1/16-in. larger in diameter than the pattern. Then as the cone passes up through the mold, the sand expands behind it enough to snugly hug the pattern, and when the pattern is drawn, the mold remains of the correct diameter.

A sectional view of the molding machine is shown in Fig. 4. One cylinder is shown with the pattern at the top of its stroke, and in the other cylinder the pattern is just starting upward. Just before the main pattern which carries the cone completes its stroke, the pattern for the socket of the pipe is pushed upwards by the main ram, and thus rams the socket end of the mold. The socket pattern is held up in the mold by four small hydraulic plungers until after the main pattern is lowered through the mold, when finally the small plungers let down the socket pattern, and the operation of molding is completed. The socket pattern can be seen in Fig. 5 at the lower end of the visible portion of the main pattern. The main pattern slides with a close fit through the annular socket pattern. The height at which the socket pattern stands before it is pushed upward can be adjusted by means of screws interposed between it and the four plungers. If it is found that the socket is being rammed too hard, the screws can be adjusted to slightly raise the socket pattern. There will then be less space for sand at the lower end of the flask, and the socket mold will consequently not be rammed so hard.

After the socket pattern has been raised by the ram, the measuring tube with its cone is removed from the upper end of the main pattern and in its place is put the spigot pattern, which is shown in Fig. 4. The spigot pattern is designed to form also the mold for the riser and the gates through which the molten metal subsequently enters the mold. It likewise forms the guide for the upper end of the core. It is fastened to the top of the main pattern by a key inserted in the slot which can be seen in Fig. 5. The hydraulic pressure is then removed, allowing the ram and patterns to descend by gravity until stopped by the contact of the spigot pattern with the upper end of the flask. This

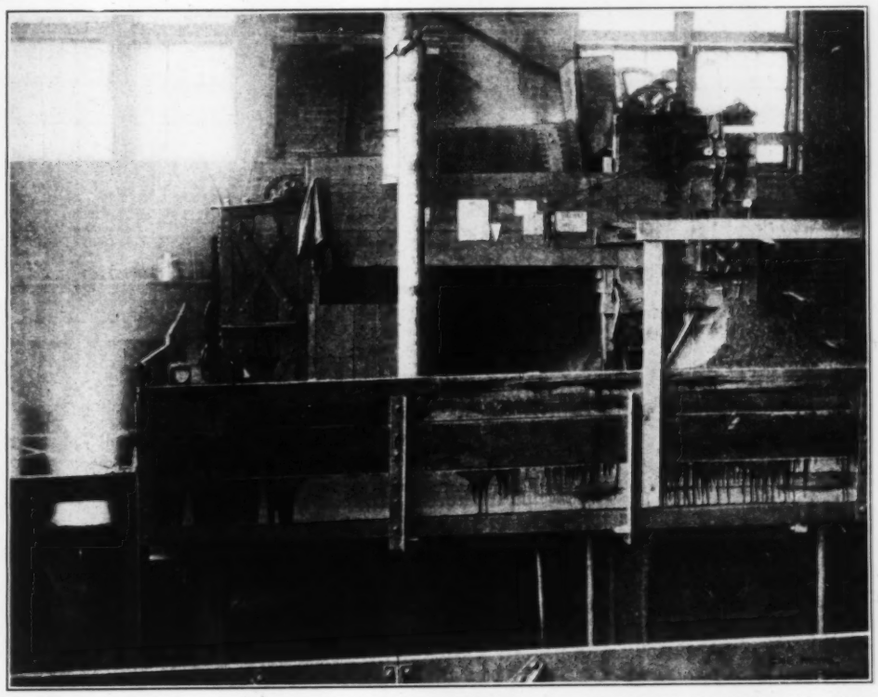


FIG. 6. MOLDING PLATFORM; SHOWING MEASURING TUBES AND THE UPPER END OF THE SAND ELEVATOR DELIVERING INTO A REVOLVING SCREEN.

(At the left on the transfer car are two flasks with molds just completed.)

FIG. 5. UPPER END OF HERBERT MOLDING MACHINE AT COSHOCTON, SHOWING METHOD OF ATTACHING FLASKS.

operation rams the upper end of the mold. The ram is now raised again so as to "draw" the spigot pattern, which is then removed, and the main pattern is drawn by simply letting it descend to its initial position. The drawing of the main pattern sleeks the mold.

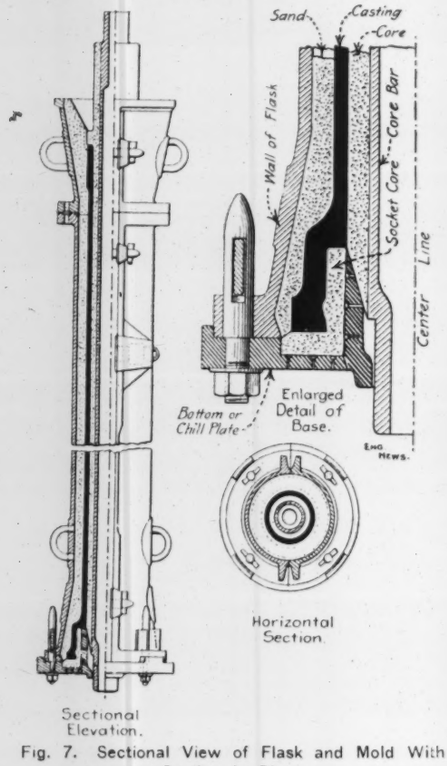


Fig. 7. Sectional View of Flask and Mold With Casting in Place.

The socket pattern is held in position while the main pattern is drawn out and acts as a stripping plate to prevent the breaking of the lower corners of the mold. Finally, the socket pattern is lowered and the mold is complete except for the cores. The flask is next detached from the top of the machine and raised with the drop-section of the runway track to the original position. It can then be pushed along onto the transfer car and started back on the return track.

For molding the large pipe (8 to 12-in.) a slightly different machine will be used. It is the same in its general principles, in that the mold is formed by a pattern pushed up through the sand from below, but the larger ratio of diameter to length necessitated a change in the arrangement of the pattern and its hydraulic ram. The ram is made hollow and is open at the bottom. Instead of sliding in a cylinder, it is telescoped over a stationary hollow pillar. Water is admitted into the pillar at the bottom to force up the ram. This construction is intended to insure a more perfect alinement of the pattern during its passage through the mold. It has the further advantage of not requiring so deep a sub-pit. The pattern is made hollow like the ram but is of larger diameter and is telescoped over the ram and secured to it by suitable fastenings at its open lower end, which fits against a flange or collar on the ram. The different sized patterns can be attached to the same ram. A small space is left between the outer wall of the ram and the inner wall of the pattern and steam is admitted to this space to heat the pattern. It is found that better molds are obtained with a hot pattern, the sand being left more evenly packed and smoother than when the pattern is used cold.

Blacking and Drying.

It will be noticed in Fig. 6 that vapor is rising from the flasks on the transfer car which have just left the molding machine. This is due to the drying of the sand by the heat remaining in the flask. The hot sand and flasks help also to dry the blacking, which is put on by a man on the molding machine platform just as the flask begins its trip along the return track. The blacking is applied with the help of a plunger which is lowered through the mold. The plunger is inserted in the upper end of the mold and the proper quantity of blacking poured in above it. The plunger is then lowered by means of a length of window cord and the blacking goes with it down the mold, coating the walls as it passes. The plunger, or dasher, is simply a cylindrical wooden block fitting loosely in the barrel of the mold. To the top of the block is secured a rubber disk of slightly larger diameter, which acts as a packing ring to hold the blacking above the dasher.

After the molds have been blacked, the flasks pass on along the runway to the drying burners. These turbines are fed with producer gas. The same producers furnish gas also for the core ovens, the ovens where the pipe are heated before being coated with tar and for gas engines which can be used to supply power for the entire plant. The burners are spaced 2 ft. apart to correspond with the spacing of the flasks. The flame is adjusted to a height of about 18 ins., so that it rises a foot or more into the lower end of the mold. The condition of the molds is inspected by the light of the flame. The volume of gas is graduated so that the burners furthest from the blacking platform give more heat than the first burners. Thus the heat is gradually increased as the molds become drier. During the drying process the upper end of the flask is kept covered by a perforated metal plate to restrict the flow of air up through the mold. (See Fig. 10.)

The time required for drying a mold is the controlling feature of the rate at which the whole process can be operated. A 6-in. mold can be dried in about one hour and 40 minutes. Since there are 25 burners under each of the parallel return tracks, the flasks can be advanced one step (equal to the distance between burners) at intervals of about four minutes. The row of flasks is moved at once, as already mentioned, by means of hydraulic rams at the end of the runway. Thus on the two drying

FIG. 8. CORE READY TO BE LOWERED INTO MOLD BY ELECTRIC CRANE.

there are two rows of flasks advancing at the rate of one flask every four minutes. In other words, the flasks are delivered in pairs at four minute intervals, that is at the rate of one flask in two minutes, or 30 flasks per hour, and the output of the pit cannot be increased beyond this point without installing longer drying tracks with more burners.

After leaving the last burner, the flasks are pushed onto the second transfer table, which returns them to the first track.

Inserting the Core.

Before the main core can be inserted, the bot-

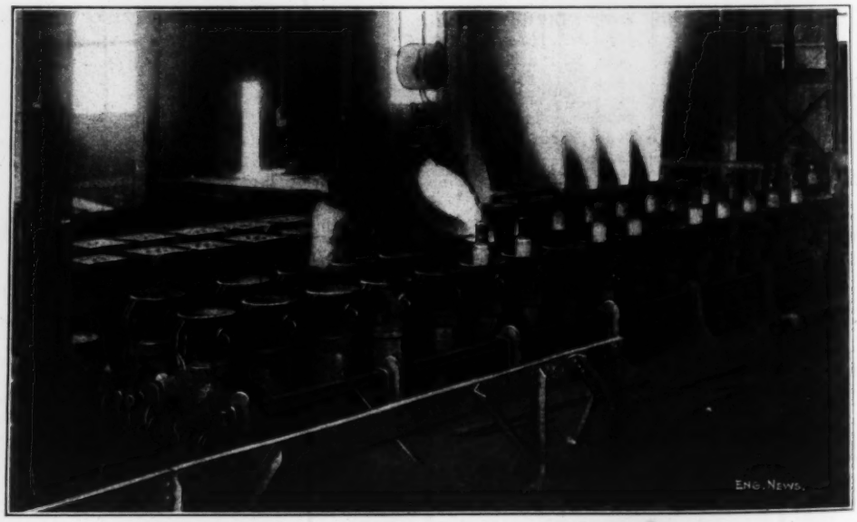


FIG. 9. POURING MOLTEN IRON INTO THE COMPLETED MOLDS.
(The ladle is hung on the hoist of a traveling crane.)

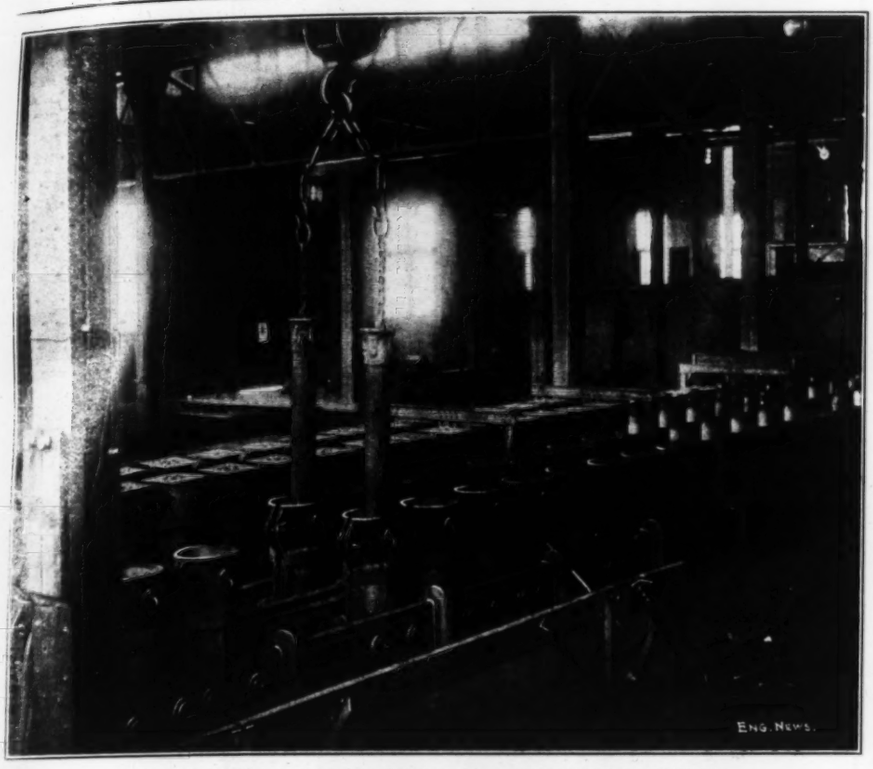


FIG. 10. REMOVING PIPES FROM THE FLASKS AFTER CASTING.
(The shrinkage head on the spigot end of the pipe is well shown here. The raised portions spaced at 90° around the head are formed by the metal remaining in the gates.)

tom plate and socket core must be put in place at the lower end of the mold, which up to this time has been left open. The bottom plate is shown in place in the mold in Fig. 7. The socket core is made with sand built up around the projection in the middle of the bottom plate. These cores are made by a man working at a bench set up in the pit at this end of the runway and are dried in an oven close at hand. As shown in Fig. 7, the projection at the center of the bottom plate has a conical socket which catches the lower end of the main core and holds it in position in the center of the mold. The lower end of the core is coned to fit this socket.

The main cores are lifted from the cars on which they come out of the ovens by a 3-ton crane and lowered vertically into the molds, as shown in Fig. 8. The fact that the flasks are held vertical by their buffers makes it easy to lower the cores quickly into position without danger of spoiling the mold. The upper end of the core is centered in the mold by a collar formed on the core, which fits into a groove made for this purpose by the spigot pattern.

Pouring and Shaking Out.

As soon as the core has been inserted the mold is ready to be poured. The number of molds to be poured at one time depends upon the relation between the capacity of the ladle and the weight of iron required for each pipe. The ladle used at Coshocton holds about 3,000 lbs. of iron, which permits the pouring of eight or ten 6-in. pipe at one time. The ladle is brought from the cupola by a 5-ton traveling crane and lowered into position beside the runway. The ladle is tipped by hand by one man by means of a geared hand-wheel, as shown in Fig. 9. The empty ladle is returned by the crane to the cupola, where it can be exchanged, if more iron is wanted at once, for a second ladle which has been filled in the meantime.

After the pouring, the 5-ton crane returns to the runway to draw the core bars from the molds. The bars are drawn in pairs by means of the yoke shown attached to the crane hook in Fig. 10 (which shows the same yoke in use for shaking out the pipe). The core bars are placed by the crane on a push-car running on a track close beside the runway. When the car is loaded it is pushed by hand back along its track to the core strikes, where the core bars are again put into use. After the core bars are drawn, chains are lowered through the center of a pair of molds and attached to the pipe at the lower end. The chains loosen some of the sand remaining in the pipe as they pass through. The flasks are then opened and the pipes are lifted out by the crane, as shown in Fig. 10. Holding-down rails are provided as shown in Figs. 9 and 10 to prevent the flasks being lifted from the pit if the core bars or castings should stick.

The operation of removing the casting at the same time loosens the sand in the flask. The sand falls through a grating and shaking screen into the trough of the tempering and mixing machine from which it is conveyed by a bucket elevator to the rotary screen on the molding machine platform, shown in Fig. 6. A clay-wash mixer is mounted in the pit close to the boot of the bucket conveyor so that clay wash can be added to the sand at this point as required. The arrangement of the sand handling plant is shown in Fig. 11.

The flasks are closed up again by hand after being shaken out, and are pushed by hand the short remaining distance to the molding machine. Ball bearings were used on the wheels of the 6-in. flasks at Coshocton, but have not proved altogether satisfactory. In the new plant for the larger sizes of pipe Hyatt roller bearings have been used. Some trouble is experienced in opening and closing the flasks at the pit first put in operation on account of the sticking of the transverse rollers. The rollers are sometimes locked rigid by cast iron spilled from the ladle in pouring. This trouble has been dispensed with in the newer plant by housing the transverse rollers under protecting shields or casings.

Cleaning and Testing.

The pipes lifted from the molds are put down by the crane across a pair of skids about 8 ft.

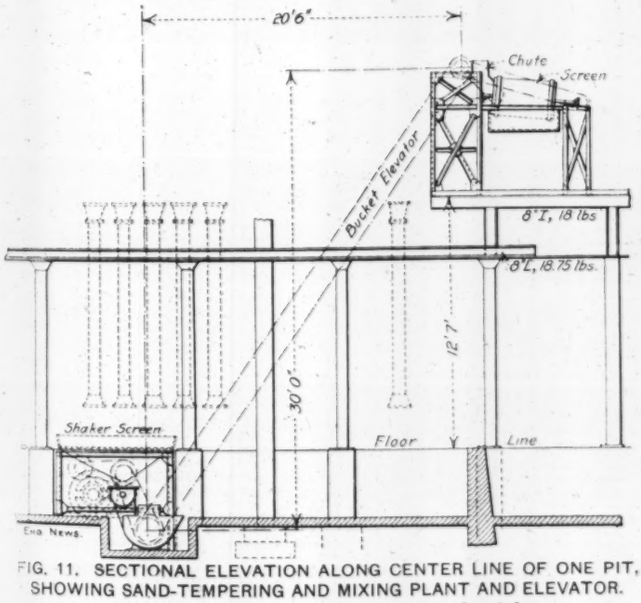


FIG. 11. SECTIONAL ELEVATION ALONG CENTER LINE OF ONE PIT, SHOWING SAND-TEMPERING AND MIXING PLANT AND ELEVATOR.
(View from the side opposite to that of Figs. 3 and 6.)

FIG. 12. LATHE FOR REMOVING SHRINKAGE HEAD AND FOR TURNING BEAD ON SPIGOT END OF PIPE.
(Two tools are shown, mounted on opposite sides of the pipe in the lathe. Another pipe is shown on the skids leading to the lathe at the right. After being machined, the pipes are rolled out of the lathe house on the skids at the left.)

apart, along which they are rolled out of the pipe foundry to the cleaning shed. While passing along the skids, the pipes are cleaned by tapping and scraping, after which they are passed along to the cutting-off lathe shown in Fig. 12. The lathe is so arranged that the pipe drops into position on the lathe bed as it rolls in along the skids. About two minutes is required to cut off each pipe. The lathe at the same time turns the bead on the spigot end of the pipe.

From the lathe-house the pipes pass on along the skids to the tar tanks. They are first rolled into an oven and heated by producer gas to a temperature of 300° or 400° F. The heated pipes are dropped into a tank filled with molten tar which has been recovered as a by-product from the gas producers. In lifting the pipes from the tar tank, one end is held higher than the other so that the surplus tar runs out of the pipe, leaving it neatly coated inside and out. The tarred pipes are rolled along the skidway to the testing-house, where they are subjected to a hydraulic pressure of 300 lbs. per sq. in. After passing this test, the pipes are rolled onto a scale and weighed. The weight of each pipe is marked upon it with white paint and it is then rolled out into the shipping yard.

FIG. 13. FIRST-COAT CORE STRIKE OR LATHE WITH COATED CORE IN PLACE.

(The core bar for the next core is suspended at the level of the men's heads. The hay for winding the bars is piled on the floor near the machine, while the mud is on a table at the rear. The collar for centering the upper end of the core is shown on the core in the machine.)

Labor and Power Required.

The number of men needed to operate the pipe-casting plant is 32, 16 in each pit. Four of these work at the molding machine, two at the platform and two in the pit below. Two men are required for the blacking—one on the platform and one in the pit. One man makes the socket cores. One man operates the 3-ton crane for placing the cores and another the 5-ton crane used for pouring, drawing the core bars and shaking out. Two men are employed at opening and reclosing the flasks, two operate the push-car that takes the core bars back to the core strikes and one man rolls the completed castings along the rails leading to the cleaning shed, the others assisting generally.

The several hydraulic rams used at the molding machine and for moving the flasks along the runway and for operating the transfer cars are supplied with water from a single hydraulic accumulator, where it is stored at a pressure of 300 lbs. per sq. in. The accumulator piston is 24 ins. in diameter and has a stroke of 12 ft. Water is supplied to the accumulator by a three-throw double-acting pump driven by a 100-HP. electric motor. The other power required in the pipe-casting pit is that for a 5-HP. motor, which drives the bucket elevator and the sand-mixing plant, and for a 2-HP. motor on the clay-wash mixer.

Core Making.

The core ovens and core-forming machines are conveniently located beyond the end of the casting pit just at the left of the view shown in Fig. 8. At the end of the building farthest from the pit are placed the mills for grinding the core mud. One mill, of the ordinary Chilian type, driven by a 20-HP. motor is provided for each pit. From the mills the mud is taken to the first core strike, which is shown in Fig. 13. The core bar is first wound with hay and then coated with mud while being rapidly revolved in the machine. A straight edge or strike is used to give the mud coating a true cylindrical shape. An extra ring of hay wound on the bar near one end forms the foundation for the collar on the core which later serves to center it in the mold. A dozen cores at a time are transferred on a suitable car into the first-coat oven. From this oven they pass to the second core machine, where another coat of mud and a finishing coat of blacking is applied. Then, after being baked in the second-coat oven, the cores are ready for use and the core cars are rolled out on the tracks close to the end of the casting pit, where they can be conveniently picked up by the 3-ton crane.

We take this oportunity to express appreciation of the courtesies and information furnished by Mr. Aland and Mr. Herbert to the member of our editorial staff who visited the Clow plant at Coshocton and also by Mr. Fred Herbert, Jr., who is Superintendent of the pipe department in charge of the continuous casting pits.

The Strength of Sheet Piling.*

The magnitude of the stresses in sheet piling, due to bending, depends upon the kind of material retained by it. Sheet piling is generally held in place by a wale at the top, one at or near the bottom of the excavated trench or area, and sometimes at intermediate points. In deriving the following formulas all weights are expressed in pounds per cubic foot, all distances in feet, and all bending moments in pound-feet. A vertical strip of piling 1 ft. wide is considered for the sake of convenience. Experimental investigations are being made by Prof. A. P. Mills at the College of Civil Engineering, Cornell University.

1. PRESSURE DUE TO WATER.—Let the ap... be assumed at the water surface and the lower ... the bottom of the excavation, or at a distance ... the surface of the water, both wales being braced. By the methods of mechanics the greate... ing moment is found at a distance 0.577 D below ... face, if the piling be treated as a simple bea... point is farther from the middle of the unsu... length than in any other case where one or mo... tional wales are employed. The eccentricity mi... ever, be regarded as offset by the partial con... the lower end which penetrates the soil, and ... greatest bending moment may conveniently be ... the middle of the unsupported depth.

The value of the greatest bending moment ... the weight of a cubic foot of water being take... lbs. If an additional wale be located at a height ... the bottom one, the greatest bending momen... them is 3.91 (2 $C^2D - C^3$). In case both the to... termediate wales be omitted the bending momen... bottom is 10.42 D^3. If the fluid material retain... sheet piling is heavier than water the press... bending moments are proportionally increased.

2. PRESSURE DUE TO DRY SAND.—Acc... Coulomb's theory the horizontal pressure (lbs. per ... for material which assumes a slope of 1.5 to 1 ... $W H \tan^2 (45° - \frac{1}{2} R)$, in which W is the weight pe... foot of the material, H the depth at which the pressure occurs, and R the angle of repose expressed in ... This indicates that the pressure varies dire... the depth as in hydrostatic pressure, but that ... weight of the material is $W \tan^2 (45° - \frac{1}{2} R)$ instead of W. In the material under consideration it is observed that the trench may be excavated a foot or more below the bottom of sheeting without causing any flow, and hence it may be assumed that the pressure is zero at the bottom as well as at the top.

It has been observed also that the center of pressure against sheet piling is not at one-third of the depth from the bottom, but more nearly two-thirds of the depth (see "Earth Pressure and Bracing," by J. C. Meem, Trans. Am. Soc. C. E., Vol. 60, and the accompanying extended discussion). It seems, therefore, that the angle of repose for any given material is not constant but varies in some manner, although not directly as the depth. In conformity with these facts R may be taken equal to $90° (H/D)^{0.6}$. The exponent 0.6 is based on the result of observations.

For material having an angle of repose ... which corresponds to a slope of 1.5 to 1 ... formula gives a horizontal pressure equal to 0.12 W ... and the overturning moment about the base of 0.04 W ... which is claimed by Sir Benjamin Baker to be double the true value. From the results of Trautwine's experiments on overturning moment due to dry sand, it is computed to be 0.019 $W D^3$. By plotting the horizontal pressures derived from the values $W H \tan^2 [45 - \frac{1}{2} (H/D)^{0.6}]$ for different depths, the total pressure for dry sand is found to be 0.029 $W D^2$, and the center of pressure is approximately two-thirds of the depth of the excavation from the base, making the overturning moment 0.019 $W D^3$, as before.

For sheet piling resisting the pressure of dry sand when held in position by wales at the top and bottom of the excavation, the greatest bending moment occurs at a distance 0.43 D from the top and equals 0.0045 $W D^3$. When an intermediate wale is placed at a height C above that at the bottom, the bending moment becomes 0.0045 $W C^2 D$.

3. PRESSURE DUE TO WET SLIPPING MATERIAL.—There remains to be considered the wet slipping material which exerts a much greater pressure than dry sand but a smaller pressure than water. Such material produces a considerable pressure at the bottom of the excavation. To meet this condition it may be assumed that the depth at which the horizontal pressure becomes zero is 2 D instead of D. When this change is made in the previous value for horizontal pressure the results agree closely with those of observation. The total pressure above the bottom of the excavation is 0.08 $W D^2$, and the center of pressure is at $\frac{1}{2}$ D. The overturning moment about the base is then 0.04 $W D^3$.

The greatest bending moment on sheet piling supported at the top and bottom only and retaining wet slipping material is 0.013 $W D^3$ and occurs at half depth. When an intermediate support is placed at a distance C above the bottom the bending movement is 0.013 $W C^2 D$.

*An appendix to the report of the Committee on Wooden Bridges and Trestles, presented at the annual meeting of the American Railway Engineering Association, at Chicago, March, 1911. The subject of sheet piling was assigned to a sub-committee composed of C. C. Wentworth (N. & W. Ry), L. T. Hotchkiss (C., B. & Q. Ry.), I. L. Simmons (C., R. I. & P. Ry.) and Hans Ibsen (Mich. Cen. Ry.).

A 2,000-HP. HORIZONTAL DIESEL ENGINE ... been erected in the municipal electricity works of Halle-on-the-Saale, in Prussia, which, it is stated, is the largest of its type. The works in question have already five steam engines, each of 1,500 HP. The addition of a Diesel engine was decided upon because a Diesel engine can be quickly started, and will be useful as a reserve and in emergencies. The exhaust from the Diesel engine is to be utilized for the boilers. It is a four-cycle, double-acting, two-cylinder tandem engine, which running at 150 r. p. m., develops from 1,600 HP. to 2,000 HP. The engine drives a continuous current generator. The fuel is coal tar oil.—"The Engineer" (London).

A Suspended Flexible Centering for Masonry Arches as Used on the Chickahominy River Bridge, Virginia.

PHILIP AYLETT,[1] Assoc. M. Am. Soc. C. E.

The Disadvantages of Rigid Falsework.

Of all classes of falsework, the most difficult usually to erect, maintain and remove, and causing the greatest obstruction to traffic, whether land or water, is undoubtedly the ordinary rigid timber falsework, usual in the construction of arch bridges of masonry or concrete, especially the latter.

The falsework of bridge arches is constantly subject to damage by fire and water, resulting in frequently complete destruction of the incompleted and supposed structure.

Excessive movements in falsework from timber shrinkage or settlement prior to or at the time of striking the centering have proved productive of permanent injury or even complete destruction. For example, the author was recently constructing a concrete arch over a small stream 100 ft. wide, by the ordinary rigid timber falsework method, when a sudden rise in the stream and accumulation of drift, resulted in the loss of both falsework and partially completed arch. Many similar cases are upon record. In several known cases the falsework was destroyed by fire, the origin of which was probably due to shavings, chips, etc., left by carpenters constructing the timber falsework.

In a number of cases of record, washout of falsework by a sudden freshet has resulted not only in disaster to the structure being built, but also other structures spanning the same stream below have been swept away by the floating falsework timbers.

One case is known where injunction proceedings were instituted against the construction of the falsework for a proposed concrete arch bridge by the owners of a highway bridge located over the same stream, several miles below. As a result, the concrete structure was abandoned and one of steel substituted therefor. Loss of life and property have frequently resulted from the proximity of falsework (supporting overhead structures) to railway tracks under traffic. In one case a bridge was being constructed over a cut containing the tracks of an important trunk line. The falsework was struck by the contents of an improperly loaded flat car, thus causing derailment which resulted in loss of life, destruction of falsework, and blocking of traffic. Numerous like cases are recorded of similar accidents from rigid falsework. The presence of falsework in streams subject to floods, ice, drift, etc., always invites disaster.

In almost every case of the loss or damage to arch bridges during construction, or subsequent development of cracks, the failures, weakness or even small settlement incidental to the construction, maintenance or removal of the so-called rigid timber falsework is usually responsible. It has been found impossible to guard completely against such occurrences to timber falsework, especially in streams or upon soft ground, even when pile foundations are used, and there are few engineers with extended practice in arch construction whose experience has been exempt.

In addition to the risks, delays, etc., involved by the use of rigid falsework, its expense is usually the largest factor in the cost of arch bridge construction. Its cost, as well as its risks and dangers, increasing out of all proportion with increase of span and depth. The usual demand in the engineers' specification for "absolutely rigid and unyielding" falsework in arch bridge construction has become both difficult and dangerous to meet under the heavy loads of modern long span arches, and this demand must, of course, add largely to cost by requiring expensive foundations, skilled construction, low working stresses, and, consequently, heavier timbers and more of them in order to eliminate shrinkage settlements and ensure the rigidity and strength required during the long periods of falsework maintenance prior to striking centers.

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Steel bridge construction does not require falsework so invariable in level and form as do those of concrete and masonry; therefore they require less timber, shorter erection time, with no delay in striking centers, and thus less risk and expense.

Thus the main handicaps in the cost and feasibility of concrete in comparison with steel structures is obviously due to their rigid falsework methods of construction. Comparisons are especially unfavorable to concrete bridges over those locations which involve unusual risks or require structures of spans and depths above ordinary dimensions. In many locations the cost of rigid falsework is not only altogether prohibitive, but the method is impossible on account of the nature of the stream or location to be spanned. Such cases occur with deep ravines, torrential streams, gorges and railroad tracks. In every such difficult location, steel structures or suspension bridges are almost invariably used, in spite of their constant maintenance and renewal cost, and the further fact that the steel is made and fabricated perhaps hundreds of miles away, with consequent high freight charges, high cost of material and the necessity of importing skilled mechanics and costly appliances to do the work. Concrete structures for such locations are rarely considered, although every material necessary for their construction, such as stone, sand, and cement, is placed by nature at or near the site, ready to be incorporated and molded by native labor with simple appliances made on the spot. Improvements in the quality of material have greatly increased the span length of steel structures and improvements in design, fabrication and erection methods, tending to partial or complete elimination of falsework have decreased risk and cost. The disadvantages of steel structures have been largely offset by their comparative economical and safe erection methods. The first cost of concrete bridges increases with the advances in the cost of timber, with no diminution of the risk and costs usual in the construction, maintenance and removal of their rigid timber falsework. In fact, so far as the first cost is concerned, regardless of other considerations, it appears that the increasing scarcity of the timber supply will render future competition between steel and concrete structures more unfavorable for ordinary locations, or even those locations especially adapted to concrete. The heavy annual drains upon the timber supply coupled with its misuse and with forest fires will bring their sure result. All kinds of timber are becoming scarce and their prices higher. Even the South and West, which for years have been the source of supply of many Eastern States, have resorted to methods of timber preservation. Timber preservation, while of value in reducing the expense of timbers which must constantly be renewed, such as fence posts, railroad ties, mine timbers, trestles, telegraph poles, and the like, can obviously be of no practical value in the construction of temporary structures, such as falsework of arch bridges. At the present rate of consumption, the exhaustion of the supply of structural timbers in the United States is not very far off. Especially is this true of the long and heavy square timbers and piling so necessary in rigid falsework construction for masonry or concrete arch bridges. With the great weight incidental to recent long span arch construction, the future demand for structural material for falsework will be greater than in the past. To meet this demand there are two methods available; both unpromising. These are by prolonging the life of the forests by wise use, and the use of structural steel or a combination of timber and steel.

With the most efficient management many years would elapse before the supply of heavy timbers suitable for rigid falsework will increase in quantity or decrease in cost. It appears, therefore, that even the present generation must resort to the other alternative, viz., the use of structural steel or a combination of timber and steel. As a result of the cost of timber falsework and the greater risks incurred with increase of weight, height and span length, a number of recent concrete structures have been built (or are now under construction) with a combination falsework, or with a falsework exclusively of structural steel.

Thus far, however, the use of structural steel falsework for concrete arch bridges has been restricted almost exclusively to those locations where the character of the stream or crossing rendered timber and pile falsework impossible or expensive. The approaches of the Manhattan Bridge (New York) were erected by combination falsework, consisting of wooden columns and struts combined with steel diagonals and connections. By reason of the decreased weight, due to the diagonals and the facility of making pin connections with angles permanently bolted to wooden columns and the interchangeability of corresponding members, expense and time was saved in the erection and removal of falsework. Falsework of this character is capable of repeated use.

Another notable example of a combination timber and steel falsework is found in the construction of the great 233-ft. Walnut Lane Arch over Wissahickon Creek, Philadelphia.[2]

Settlements caused by the compression and shrinkage of this great mass of timber under the enormous superimposed weight for so long a time nearly caused disaster to the partially completed arch ring in spite of the utmost care and vigilance in its design and construction.

In a paper before the American Society of Civil Engineers[3], the designer of the structure stated as follows:

> The stresses in the woodwork were high enough, apparently, to produce progressive deflection, so that, during the time of loading and subsequent seasoning, the falsework compressed sufficiently to lower the crown 3¾ ins., this amount being the same for both ribs. In anticipation of this compression the falsework was originally set higher than the plan elevation. * * *
>
> No actual failure occurred at any point, but it was evident that if the structure had been required to sustain its maximum load much longer some of the falsework would have collapsed.
>
> * * * * * * *
>
> The action of the falsework indicated that the unit stresses to which the wood was subjected, in side grain bearing at least, were beyond its elastic resistance, and it is recommended, therefore, that the working stresses of wood in side-grain bearing, even for temporary duty, should be limited to 500 lbs. per sq. in., and that the details should be made as compact as possible.

The design of the Sitter Arch[4] in Switzerland not only carried out this suggestion, but even went a step further. The falsework of the 259-ft. Sitter Arch was over 200 ft. high, and to a limited extent a combination falsework of wood and metal. Its settlement was only 1¼ ins., which is attributed to the high character of workmanship and extensive use of hardwood and channel iron corbels, and by limiting the cross grain compressive stresses to 250 lbs. per sq. in., or half as much as was recommended by the designer of the Wissahickon Arch.

In view of the experience of the builders of the Wissahickon Arch these were evidently wise precautions, although adding largely to falsework cost. The roadway of the Sitter Arch is 261 ft. above the creek level, and 580 M. ft. of timber were used in the falsework and 50 tons of steelwork and bolts. This falsework would cost in the United States $30,000, and $40,000 if constructed under the Swiss specifications.

The first recorded use of falsework entirely of structural steel for concrete arch bridge construction on a large scale, was in 1909, upon the construction of five 150-ft. channel spans of the Delaware, Lackawanna & Western R. R. Bridge over the Delaware River.[5] The Delaware River is subject to heavy floods with ice and drift. A concrete structure could, therefore, never have been considered at all, but for the elimination of the ordinary pile supported rigid falsework and the introduction of structural steel falsework. This latter consisted of three centered steel arches supported upon concrete projections on the piers designed for the purpose. Thus an unobstructed passageway was provided for floods, drift and ice. Two complete sets of these steel arch centers were provided in order that two adjacent concrete arches could be constructed simultaneously. These steel arches were erected, dismantled, and removed from span to span by their manufacturer. The 280-ft. concrete arch span over the Rocky

[2]Engineering News, Jan. 31, 1907, p. 117; Aug. 15, 1907, p. 168.
[3]Transactions of the American Society of Civil Engineers, v. 65, Dec., 1909, p. 423.
[4]Engineering News, Aug. 5, 1909, p. 133.
[5]Engineering News, Dec. 30, 1909, p. 713.

River*, at Cleveland, Ohio, is another interesting example of structural steel falsework. This arch consists of two plain concrete ribs, each 22 ft. in width by 11 ft. thick at the springing line, and tapering to 18 ft. by 6 ft. in height at the crown. Here, as in the case of the D., L. & W. Delaware River Bridge, the danger from flood and ice placed timber falsework out of the question, and steel centering composed of two parallel three centered steel arches was used. The cost of the steel centering at Rocky River was actually less than timber falsework. This economy was effected largely by the temporary use during erection of a large number of 20-in. I-beams, which were afterward embedded in the permanent floor. At the completion of one arch rib, the entire steel centering was shifted bodily for use in construction of the second rib, as was done at the Wissahickon Arch.

It cannot be denied that the cost of concrete arch bridges increases as the timber supply decreases, and that there are many locations in which steel is now used where concrete was not considered at all, or if considered in comparative estimates with steel was finally abandoned as unfeasible or impossible, after taking into consideration risks, expenses, etc., incidental to the erection, maintenance, and removal of rigid falsework.

The use of a new method of arch construction as used at the Chickahominy River, Richmond, Va., and in other work, has demonstrated that it possesses many advantages and possibilities, in addition to economy and rapidity of construction. Since this method as used at Chickahominy River involves the use of no falsework whatever, the great expense, risks, etc., incidental thereto are eliminated and thus a means is afforded of constructing concrete arch bridges over those locations heretofore considered impracticable, expensive, or altogether impossible, by reason of falsework considerations, difficulty of access, or remoteness from civilization.

Prior to the detailed description of methods, etc., used at Chickahominy River, a brief review of some of the most important experiments, test arches, etc., preceding and leading up to its use there, will be of interest.

Preliminary Experiments and Description of Methods of Constructing Arches Without Centering.

The method was first suggested by an actual experience with rigid falsework supported on piles during construction of a 70-ft. concrete rib span. Skin friction of the piles was reduced by scour after a heavy freshet and caused the sinking of the piles supporting the falsework, which, of course, threatened the destruction of the concrete ribs. Fortunately, the concrete ribs had been deposited in voussoirs, and the spaces between them had not been filled with concrete when the settlement of fully 12 ins. occurred, decreasing towards the abutments.

Jacks were placed upon the caps of the pile falsework bents, which were located directly under the open spaces between the concrete rib sections. The rib sections were thus raised to the true curvature, as determined by computed ordinates between the intrados and a horizontal line (as shown by targets). The open spaces between the rib sections were then filled with concrete. Although sinking still continued, the true curvature was maintained by the jacks, until the concrete was set up, and the arch became self-supporting. This structure has now carried heavy traffic for eight years.

All specifications covering the construction of masonry or concrete arches and their falsework provide for possible settlements, by raising the falsework. This can be nothing more than a guess on the part of the designer or erector, and, as a result, there are few, if any, arches now extant which have their correct intrados curvature and elevation. They either have settled not as much as anticipated, or more. If the falsework has been "rigid and unyielding," as usually specified, no settlement occurs, and the intrados never assumes the correct curvature. Maximum settlements in falsework usually occur prior to the self-supporting stage of the structure, or completion of the arch ring, as in the above case. These settlements are not uniform or of equal amounts from end to end, but vary, showing that each supporting timber or pile bent has a settlement of its own, thus forming a series of hinges or points of flexure in the lagging, as it were, their movement depending upon the amount of load, its location, sequence of placing same, its weight and the character of the foundation, soil, etc., upon which the falsework is built, and upon the falsework itself. The movement of the lagging near the crown is often upward, unless the arch is loaded at that point prior to loading elsewhere.

After the success of the above emergency work, two experimental arch ribs were constructed upon falsework. One of these ribs was composed of sections which were molded in place, which, after being properly adjusted for curvature were keyed together by pouring concrete keys in the key spaces between the sections. The other rib was composed of two previously molded sections, supported upon hinges located at the abutments and crown. Adjustments being made prior to keying or hinging by raising or lowering the crown ends of the two sections by means of jacks, placed upon one point of support, located under the crown. When the concrete keys were set, or the pins or hinges placed between the sections as the case may be, the temporary supporting structure is removed, leaving the arch self-supporting.

It will be seen that the above method makes it possible for the temporary supporting structure to shrink, stretch, settle, or otherwise become distorted without injury to the incompleted arch, since the arch section can, at any time, before keying them together, be accurately adjusted. The arch sections may be formed on the centering or molded elsewhere and then placed in position, as stated, the sections being of any desired length.

When the sections are previously molded, the amount of temporary falsework is much reduced, this reduction depending upon the length of sections.

For instance, if the arch rib was composed of four sections, only three temporary supports in conjunction with abutments would be necessary. If the ribs were composed of only two previously molded sections, a temporary support at the center would only be required, the two sections being either keyed at the abutments and crown with concrete, or hinged, as desired. This method, in addition to the economy effected by the partial elimination of falsework, is important in the construction of very heavy long span arches, which necessarily require maintenance of their falseworks for long periods, with consequent distortion and injury due to shrinkage, settlements, etc.

The above methods, while eliminating injury due to shrinkage, settlement, etc., also reduces the amount of falsework therefore effect much saving and are useful in many locations.

The foregoing work and experiments suggested the Flexible Support or Suspended Method, by which arch construction has been made possible without the use of any falsework whatever. While the method can be used for almost any location, it is especially adapted to rapid and economical construction for such locations as deep gorges, rapid streams, canals, railway tracks, etc., etc., over which, heretofore, any method of concrete arch construction has been found impracticable or altogether impossible.

GENERAL DESCRIPTION OF FLEXIBLE SUPPORT METHOD.—Fig. 1 is a sketch showing the application of this method to the construction of an arch rib.

Cables are hung from suitable supports, such as A-frames or towers, located on or near the abutments. The cables are anchored by any convenient and suitable method, an ordinary dead man at each end of the cables for spans under 150 ft. being generally sufficient. Depending from the cables are the hangers, carrying the cross members of wood, iron rods, steel shapes or pipes. The longitudinal members are composed either of wood or steel shapes, such as angles or channels, as desired, and rest upon the cross members, so that by lengthening or shortening the hangers, the series of supports can be made to assume any desired curvature according to the design of the arch which is to be erected. Each cross bar or pivot passes through holes or slots in the ends of the longitudinal members (or in notches cut in their bottom edges), so as to permit the curvature of the arch to be varied. The end sections adjacent to abutment skewbacks may also be suspended by hangers from the cables, but it is sometimes preferable to support them upon suitable hinged bearings directly on the abutments, without suspension at this point from the cables. The series of longitudinal members, flexibly jointed together, constitute in effect a flexible centering upon which may be laid the previously molded voussoir sections of the concrete arch rib, or molds in which the concrete ribs or sections can be cast directly upon the suspended centering.

The length of the hangers are determined (approximately) in advance, so that when the cables and flexible centering are in place the latter will have the approximate curvature, but to permit of final accurate adjustment at any time, the hangers are provided with turnbuckles 11, whereby they may be readily let out or taken up as desired, so as to correct the curvature of the centering whenever necessary. It has been found satisfactory to use wire rope suspenders instead of rods, and for very heavy spans differential pulleys may be used for adjustments, without the use of turnbuckles. Hanging from the ends of the cross bars or pivots is a row of targets (or plumb bobs) on wires or rods of such length (determined by calculation) that when the curvature of the flexible centering has been adjusted correctly the targets will all be at the same level. Thus, under the direction of a leveler on the bank of the stream, or an adjacent pier, the sag of the cables and the lengths of the hangers can be varied until the targets are all at the same level, whereupon it is known that the centering, and, therefore, the concrete segments (or voussoirs) of the permanent structure are in proper form. Extending through the molds are the reinforcing bars, which may either run continuously, forming lap joints in all key spaces, or be rigidly connected by one of several methods.

A few years ago it was considered essential in concrete arch construction to have the ring a solid monolith from spring to spring. For long spans, to effect this, continuous work, night and day, was specified. With somewhat longer spans, continuous work was found inconvenient and expensive—and solid barrel arches were divided into longitudinal sections of such widths that the volume of concrete contained could be deposited in a working day. Thus, the completed arch is composed of monolith longitudinal sections.

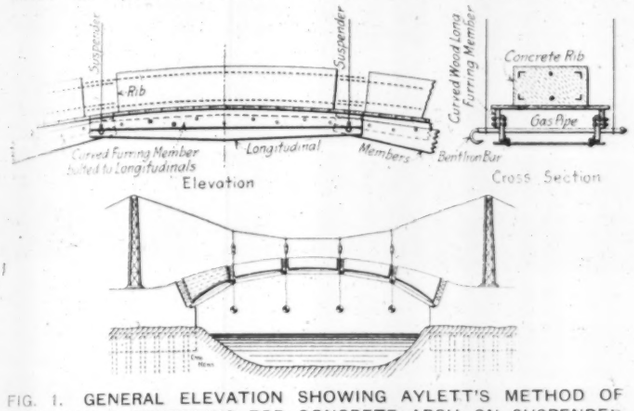
With the longer and heavier spans of the last few years, monolith arch ribs and barrels (even in longitudinal sections) were found impossible. Experience in arch design and construction has shown such practice an unnecessary precaution and expense, with hingeless arches. In fact, monolith arch ribs and rings are not only unnecessary, but have been found impossible of construction in modern long spans, for the reason that proper sequence of loading rigid falsework is essential in order to guard against deformation of centering and the impracticability of continuous work, and even disaster.

In order to secure symmetrical loading of falsework and other advantages, the most recent practice in constructing arch ribs is to divide same into alternate blocks or voussoirs. With flexible support, such division is also used to afford a means of temporary flexibility, the points of flexure (or hinges) being located between the voussoirs, and the skewbacks. By this means, construction oscillations, deflections, etc., of the supporting cables have no effect upon the individual concrete rib sections or voussoirs during construction. Symmetrical loading had been found entirely unnecessary. In one case—with cable support—an arch rib was begun at one abutment and completed continuously to the other abutment. In another case, the arch rib was commenced at the crown and continued to the abutments. When the concrete in the sections sets up the forms are removed and the spaces between the concrete rib sections enclosed by forms. The key spaces are then filled with concrete, embedding the reinforcement and keying the arch sections together.

Where two or more arch ribs are constructed

*See page 722 of this issue.

with flexible support, side by side, they may be connected by transverse beams, cast in forms extending between the arch forms at suitable points, preferably opposite, and in communication with the key spaces, so that the transverse beams and keys will be integral or monolithic. Reinforcing bars may be provided, extending through the transverse beam forms and connected with the longitudinal reinforcing bars. Since the longitudinal members of the centering members are preferably curved, furring members (preferably wood) having their upper edges curved to the intrados of the arch structure, are rigidly attached by cleats or otherwise to the longitudinal centering members. The furring members are also supported at their ends upon the cross members. Thus by substituting differently curved furring members and adjusting the length of the hangers, an arch of any curvature and length may be constructed with the same apparatus, within the capacity of the cables, etc. The arch ribs being completed, the cables and centering may be taken down and a superstructure of any desired character constructed upon the completed arch ribs; or the main cables may now be



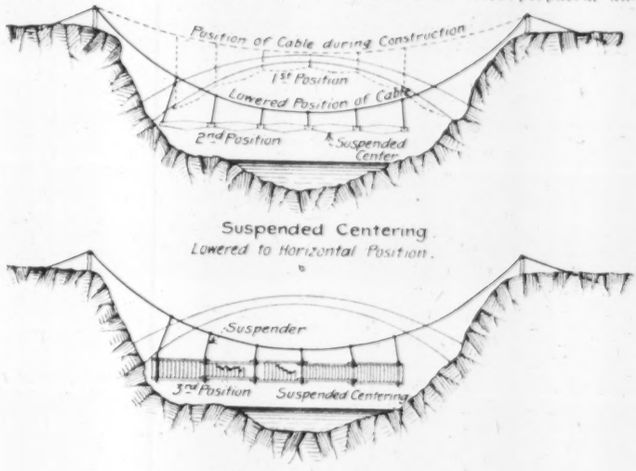


FIG. 1. GENERAL ELEVATION SHOWING AYLETT'S METHOD OF CARRYING CENTERING FOR CONCRETE ARCH ON SUSPENDED CABLEWAY.

slacked off until the suspended centering drops from 3 to 5 ft. below the intrados of the arch, and in this position used as a suspended scaffold for the workmen to finish up the surfaces of the completed ribs. The cables (when not required for immediate use elsewhere after completion of arch ribs) may also be freed from hangers and suspended centering, then hoisted above the grade of the proposed roadway, and in this position used as an ordinary cableway for delivery of concrete from the mixers on shore to the spandrel and roadway forms, from either direction or from both banks of the stream or from barges in the stream below. In the construction of heavy spans requiring supporting cables of large diameters, it is best to use a special cable of small diameter for the delivery of material, this supported upon the main cable supports, thus avoiding wear and tear upon the main cables. Thus the expense and delays incidental to the transportation of concrete on runways by carts, cars, etc., is eliminated.

While the suspended system is especially adapted to the rapid and economical construction of rib bridges of the hingeless, two-hinged or three-hinged type, it may also be used in the construction of solid ring arches with or without hinges. By the introduction of hinges, not only are the stresses more readily determined, but it also becomes possible to lighten the rib design and reduce by so much the load on the cables.

Further than this, much of the weight of the two concrete rib segments adjacent to the two abutments being supported by the abutment hinges, the weight upon the cables being thus reduced, the dimensions and weight of cables, anchorages, etc., are also correspondingly reduced. The end segments of the arch rib being pivoted by the hinges or pivots on the abutments are free to respond to the small construction oscillations of the cables due to depositing concrete, etc., in the intermediate segments, and the open joints or key spaces between same.

Fig. 2 is an elevation of an arch rib completed over a stream, showing one method of shifting the suspended centering from a completed rib to the location of a proposed adjacent rib in the same structure. The procedure is:

(a) The main cables are slacked off until the flexible centering assumes a horizontal position.

(b) The suspenders are released from one end of the cross-bars allowing the centering to drop to a vertical position, free from the completed rib.

(c) Cables and centering moved laterally to position for adjacent rib. Released suspenders again attached to cross-bars and entire centering raised to proper position by tightening main cables.

PLASTER OF PARIS ARCHES.—Prior to actual construction of arches in concrete, the method of arch rib construction by casting the voussoirs in place upon suspended flexible centering was demonstrated by constructing a number of plaster of paris arches, all of varying curvature, and with span lengths ranging from two to five feet. In this model the towers were of wood and the cables of ordinary picture cord. The suspenders from the cables were cut from the threaded ends of wire bicycle spokes. The cables and suspenders were provided with miniature turnbuckles for adjustment of curvature. The suspended flexible centering was made in white pine.

The abutments were cast first (in plaster of paris) and then the arch rib segments cast in forms or molds placed on the suspended centering, with the key spaces left open. After the plaster of paris has hardened sufficiently in the rib segments and the suspenders adjusted by their turnbuckles for true curvature, the key spaces were filled. When the plaster of paris keys were hardened, the suspended centering was struck instantaneously throughout the length and breadth of the arch intrados, by slacking off the little turnbuckles of both cables.

It may be interesting to mention in passing that several experimental arch ribs of wet sand were molded in these model suspended forms. These sand ribs were uninjured and self-supporting when the suspended centering was "struck," and the curvature perfect. Two of these sand ribs were made of clean, wet sand, with a small percentage of clay, while one other rib was composed of wet sand alone. The same experiment was tried upon the sand ribs, also sand-clay ribs (of same span and dimensions) using a model of ordinary falsework, and although great care was used in striking the model falsework, in no case was this accomplished without injury to or failure of the sand ribs.

SMALL EXPERIMENTAL CONCRETE ARCH.—After the success of these experiments, a two-rib concrete arch was designed and built. This had a span length of 10 ft. and 2 ft. rise, composed of two parallel ribs 12 ins. apart, connected by transverse beams. The section of each rib was uniform throughout, and was 3 ins. in width and 4 ins. deep.

The two abutments were built first. Two ⅜-in.

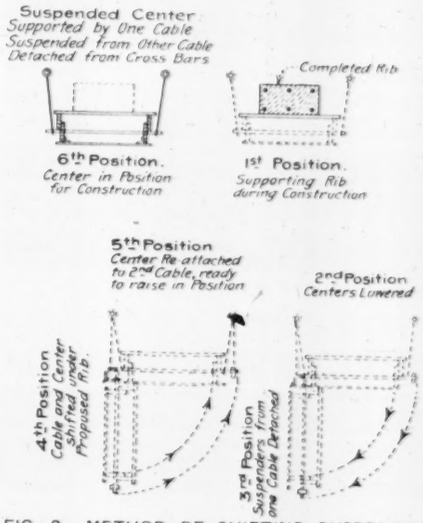


FIG. 2. METHOD OF SHIFTING SUSPENDED CENTER FROM ONE ARCH RIB TO AN ADJOINING RIB.

cables were suspended over the location of the proposed span and anchored to the tops of a back yard fence, after bracing same. The suspenders were made of small copper wire tied to the wooden cross-bars and cables at proper intervals. The volume of concrete in these ribs was so small that each rib was completed prior to the initial set of the concrete.

It was, therefore, possible to adjust the suspenders for curvature while the concrete was in the wet state, consequently no key spaces were necessary and none provided, except those adjacent to each abutment. The adjustments being made, the ribs were allowed to set up, after which the key spaces at the abutments were filled with concrete. The arch having reached the self-supporting stage, the centering was struck, merely by slackening the cables. These ribs supported ten men (all that could get upon them) within a week after completion.

LARGE EXPERIMENTAL CONCRETE ARCH.—It was now desired to make further tests upon a still larger scale. With this in view, the designs for an arch rib having a clear span of 53 ft. and a rise of 7 ft. were prepared, and the weights of arch, cable sag, etc., determined. It was found that steel cables 1 in. in diameter and suspender rods ⅝-in. in diameter would support the 53-ft. concrete rib and centering with a proper safety factor. This arch was built at Portsmouth, Va.

The rib was divided into six sections, which required six pairs of suspenders and cross-bars for their support. The abutments and towers were first built and the cables placed in position and anchored to "dead men" buried 4 ft. in the ground.

The longitudinal members of the centering were

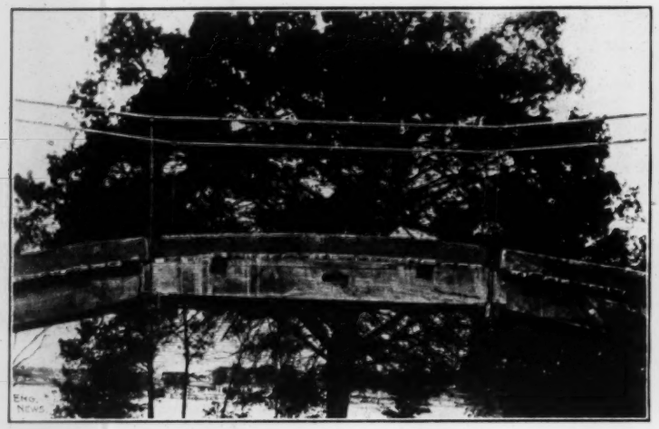


FIG. 3. VIEW OF EXPERIMENTAL CONCRETE ARCH AT CROWN, SHOWING METHOD OF SUPPORT.

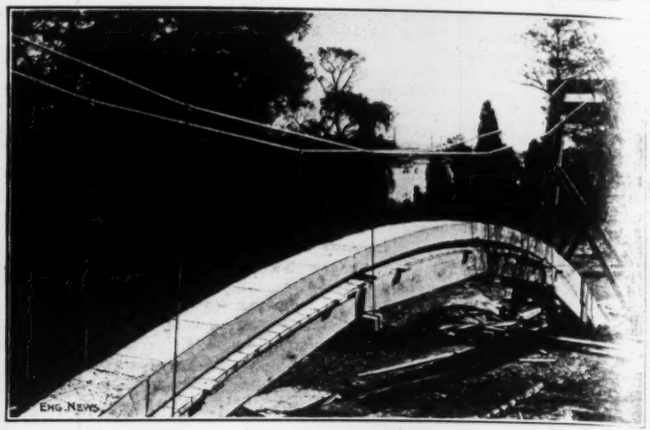


FIG. 4. VIEW OF 53 FT. EXPERIMENTAL CONCRETE ARCH JUST AFTER BEING STRUCK.

made of 2 × 10-in. plank, resting loosely upon the cross-bars with their ends overlapping. To prevent slipping longitudinally, a ¾-in. iron rod passed through the overlapping ends of the longitudinal members. No turnbuckles were used on the suspender rods in this case, but their lower ends were threaded 6 ins. so that the proper adjustments for curvature could be made by nuts under the cross-bars. Cast-iron plumb bobs were hung from each of the cross-bars, with copper wires of computed ordinate lengths. The top halves of the plumb bobs were painted white and the bottom black, to facilitate sighting when making adjustments, and thus affording a definite lower terminus for the computed ordinates.

When all concrete was deposited in the rib forms (except in the key spaces) the total deflection of the cables, due to the load, did not exceed by ½ in. their computed deflection. Adjusting the intrados curvature to the true curvature was effected by adjusting so that the plumb bobs were brought to the same elevation. It was found only necessary to tighten up the nuts under the two central coss-bars ½ in. and to slack off the nuts under the extreme end bars ⅜ in.

Twelve hours after depositing the concrete in the key spaces, the suspended centering was dropped, or "struck," simply by slackening off both cables. (Fig. 4.) This "striking" of the suspended center was effected instantaneously by a boy standing between the main cable turnbuckles near the anchorage, holding in each hand a stick, which passed through the turnbuckles and acted as a lever in turning them.

One of the greatest risks connected with the use of rigid falseworks is found in the operation of "striking the centers." Judging from experience, the striking of suspended centering is accomplished with such ease and uniformity that the usual dangers arising from shock and jar to the completed arch appear to be eliminated.

This, and the further fact that all the concrete in the arch rib is set up at the time of filling the key spaces, made possible the striking of the suspended centering of the 53-ft. Portsmouth Arch after twelve hours, and the Chickahominy River arch, 48 hours after keying.

The results of the foregoing tests were so satisfactory that the writer undertook to apply the system of construction to a bridge about to be built for the State Highway Commission of Virginia.

The Chickahominy River Bridge.

In 1909, the State Highway Commission of Virginia, in behalf of the Commissioners of the Counties of Henrico and Hanover, advertised for proposals for the construction of a highway bridge across the Chickahominy River on the Cold Harbor-Fair Oaks public road, near Richmond, Va., where there was an old structure consisting of an ordinary trestle, in bad condition, and not in keeping with present requirements and traffic.

Alternative designs of both steel and concrete were furnished by the Commission. The steel design contemplated an I-beam superstructure (with wooden floor) supported by concrete piers and abutments upon pile foundations. The alternative design contemplated a similar substructure with reinforced-concrete girder superstructure. Bidders were also permitted to submit their own designs, if desired.

The lowest bid submitted (for either steel or concrete) was that based upon the design made by the writer, employing the suspended flexible centering in the erection of the arch ribs. This design and bid were both accepted and the contract awarded accordingly.

The design of the Chickahominy Bridge, as built, provides for a reinforced-concrete structure, composed of a three-rib arch, having a clear span over the channel of 50 ft., the approaches being of beam and slab construction in panels of 13 ft. c. to c. of columns. (Fig. 5.) The length of structure over all is 160 ft. and the clear width of roadway 16 ft. The three arch ribs are similar, each having a depth of 16 ins. at the crown and 32 ins. at the springing lines. The width of each rib transversely is 14 ins. and the w
rib (including suspended centering)
ported by the cables was nearly ten tons

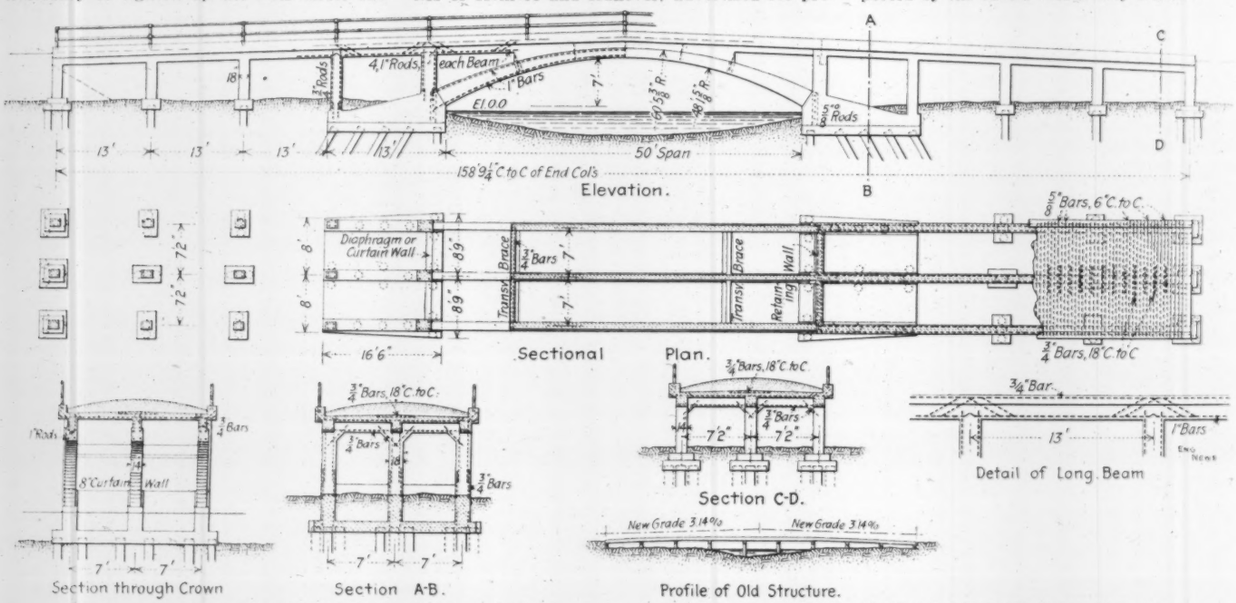


FIG. 5. DETAILS OF REINFORCED-CONCRETE BRIDGE OVER CHICKAHOMINY RIVER, HENRICO-HANOVER COUNTIES, VA.
(Erected by the suspended center method.)

As the bed of the river was of sand and gra
it was necessary to use batter piles in the a
abutment foundations. The concrete foundati
slabs are 1 ft. 4 ins. thick (embedding the hea
of the batter and plumb piles) and are slight
tapered with dimensions shown.

The arch ribs spring from skewbacks upon but
tresses opposite each. These buttresses are co
nected by reinforced-concrete curtain walls
diaphragms 8 ins. thick, located near the skew
backs, thus acting not only as horizontal tie

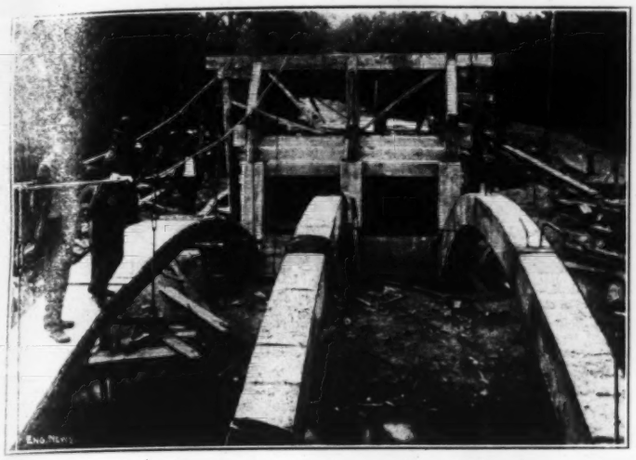
but also retaining the filling deposited in the space between the buttresses. The new structure was located up stream and parallel to the old ... about 25 ft. clear of same. The General Specifications for Concrete Bridges by Mr. ... Watson, published in 1908, were used ... sign (Class I loading).

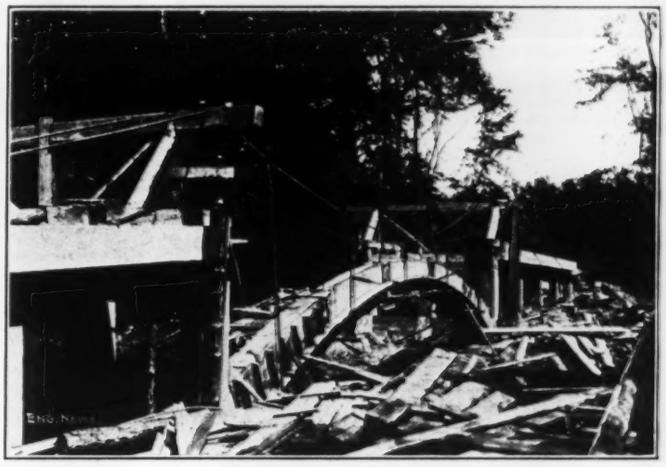
... cables and centering used in the Ports-

In order to assure perfect control at all times—in case of freshets—the main cable turnbuckles were located above the floor slab of the approaches. This location also afforded a full view of the entire ribs, intrados, suspenders, etc., to the operator at the main cable turnbuckle levers when making adjustments or "striking centers."

Previously-Molded Arch Rib Sections.

The method of flexible support lends itself to another method of construction, similar to that used in connecting with falsework described. This consists of previously molding the concrete rib sections, of any desired length, at the bridge site or other point, and suspending these concrete sections directly from the cables in the positions





FIGS. 6 AND 7. VIEWS OF CHICKAHOMINY BRIDGE DURING CONSTRUCTION.

... experimental arch were ample for this service, but it was desired to obtain cables and suspenders of sufficient capacity for future use upon span lengths up to about 80 ft. For such service, 1⅛-in. diameter galvanized steel cables and ⅞-in. diameter suspenders were obtained, provided with turnbuckles.

Both approaches were completed prior to the constructing of the arch ribs, in order that the cable supports might be mounted upon them, thus affording foundations for same and reducing their height. This arrangement reduced the height of the supports to only 4 ft. 6 ins.

The cables were anchored to "dead men" located behind the concrete columns at the ends of the approaches. Slots, or openings, were provided in the roadway floor slab of the approaches in order that the inside cables might pass through same to their anchorages. The connection between cables and anchorage was made above ground, so that in shifting the cables from one rib to another, it was not necessary to make any excavation to the underground anchorage. The cable supports were constructed of round timber, cut at the site, and timber taken from the old structure. No saddles were used under the cables on the supports at either Portsmouth or Chickahominy River. The cables simply rested in notches (lubricated) cut in the supports. Saddles are, of course, necessary in longer spans.

FLEXIBLE CENTERING.—The Chickahominy River flexible centering was even simpler than that used at Portsmouth. The cross-bars were 3-in. gas pipe, 4 ft. long. The ends of the 2 × 12-in. wooden longitudinals overlapped on the cross-bars and were notched to receive the bars—thus forming the pivots, or points of flexure. The lagging and concrete forms were nailed on top edges of longitudinal members.

ADJUSTMENT FOR ELEVATION AND CURVATURE.—After the cables were loaded by the wet concrete rib sections, only 1-in. vertical adjustment for curvature was necessary, as determined by the plumb bobs. The key spaces were then filled.

The maintenance of proper elevation, curvature, etc., was subject to such complete control that the intrados curvature upon completion was perfect in every rib. As stated, the cables and suspenders used were capable of constructing spans of 80 ft. and under. Simply by substituting differently curved fillers, or furring members, upon the longitudinals, and adding or decreasing panels of flexible centering, the plant is ready for use in constructing spans of any radius and length within the capacity of cables and suspenders used.

As soon as possible after completing a rib, the forms were stripped off in order to shorten the setting time of the concrete rib sections and keys. (Figs. 6-7.)

Forty-eight hours after the completion of the first rib, the flexible centering was struck and transferred to the second rib adjacent and thence to the third rib. After completion of the ribs and removal of cables, the spandrels, beams and floor slabs were built, and the structure completed. (Fig. 8.) The spandrels were anchored to the arch ribs by ¾-in. radial bars, as shown.

Prior to acceptance the Commissioners required the specified test to be made under the supervision of their Engineers. The specified test load was a 12-ton road roller, which was operated at various speeds back and forth over the entire roadway area, between curbs.

Although the Chickahominy was a most favorable location, with its low banks and slow current, for rigid falsework, and very unfavorable for flexible centering, yet a comparison of the actual bids received demonstrated the fact that even here concrete structures built by rigid falsework methods, or even steel structures, did not compete. The next lowest bid for a concrete structure (girder type) exceeded the flexible centering bid by $1,500. The lowest bid on an ordinary cheap steel I-beam plank floor structure exceeded by $200 the lump sum bid of $3,550 (or $1.48 per sq. ft. of roadway) submitted by the contractor using flexible centering, this figure covering the structure complete, except macadam, roadway and grading.

The work was executed by Mr. Charles McDermott, of Washington, D. C. The structure was designed by the writer, and submitted to the Highway Commission for revision and approval. Mr. Wilbur J. Watson, of Cleveland, Ohio, acted as Consulting Engineer. Mr. John Scott Banks was Superintendent of Construction, who, with Mr. H. D. Ward, rendered valuable assistance in model making and experimental work.

which they are to occupy in the finished structure. The lower ends of the suspenders would be attached directly to the concrete sections by means of projecting metal lugs, eye-bolts, or bars, embedded in the sections when casted. Thus the suspended centering is eliminated, resulting in still further economy and time of construction. The concrete sections would be coupled together longitudinally (after being suspended in place) by metal couplers, the couplers being adjustable, if desired. These adjustable couplers in conjunction with the adjustable suspenders and cables, would hold this entire articulated rib, or any part of it, under perfect control, and permits of accurate adjustment horizontally, vertically, and longitudinally at all times.

The previously-molded concrete sections being suspended and adjusted, it only remains to rigidly connect the sections and their reinforcement together, in order to reach the self-supporting stage, or completed arch. There are a number of methods for effecting this, the choice in any particular case depending upon the character of reinforcing material used, dimensions of rib sections, span length, etc.

FIG. 8. VIEW OF COMPLETED CHICKAHOMINY BRIDGE.

After accurate adjustment of the articulated rib for curvature and elevation, the reinforcing material (bars, beams, girders, etc.), would be rigidly connected by turnbuckles, lap joints or riveted splices, as the character of the reinforcement may require. When no reinforcement

is required, as in the case of plain concrete, masonry or brick arches, the open spaces between the voussior are serviceable only as points of flexure, and are reduced to the width of ordinary mortar joints—from ½ to 1 in. wide. In reinforced-concrete arches also, built by the suspended method with or without suspended centering, the key spaces also become mortar joints by providing splice-chambers, these chambers occupying only a portion of the sectional area of adjacent voussoirs. In these chambers the reinforcement connections by turnbuckles, riveted or lap-joints, are made within the ribs themselves and free from view. The splices or connections would be embedded in concrete when the open key spaces or splice chambers are filled, thus completing the arch.

Patent Rights.

The above methods of constructing arches by means of suspending concrete forms, or previously molded arch sections (including applications to erection of structural steel arches) from cables, also the method of supporting previously molded arch sections upon falsework, as mentioned, and connecting same by concrete keys, pivots, or hinges, was devised and has been patented by the writer.

The Steel Centering for the 280-ft. Rocky River Concrete Arch.

The so-called Rocky River Bridge, carrying Detroit Ave. over Rocky River, in Cuyahoga Co., Ohio, in the outskirts of Cleveland, consists of one 280-ft. main span, flanked on one side by two and on the other side by three 44 ft. arches, all of plain concrete. It has a 40-ft. roadway and two 8-ft. sidewalks and is designed to carry on two tracks 60-ton electric cars. The main arch consists of two ribs, 34 ft. c. to c. each 18 ft. wide and 6 ft. thick at the crown and 22 ft. wide and 11 ft. thick at the spring. Although no reinforcement is used in the arch ribs proper the floor system, which is carried upon spandrel columns and arches, is reinforced with I-beams and rods. At the time this bridge was started it was the largest single span masonry arch in this country and even now it is surpassed by 1 ft. only, by but one other, the Monroe St. Bridge at Spokane. The design and construction of the falsework centering for such an immense arch has therefore more than common interest.

This centering is described in the current issue of the Proceedings of American Society of Civil Engineers* by its designer, Mr. Wilbur J. Watson, M. Am. Soc. C. E., who was called in by the contractor for this work. The design of Mr. Watson was approved by the County Engineer who had immediate charge of the bridge for the county. Mr. Watson's paper is in part as follows:

The writer made preliminary plans for both timber and steel centers, including several types of the latter, and finally decided on the use of the three-hinged arch as being the most practicable and economical. Among the advantages which the steel centers possessed were the following:

(1)—Economy: These centers were estimated to be at least $15,000 cheaper than timber centering of the usual type.
(2)—Freedom from danger of being carried out by ice. It was evident that these centers would have to be in the river at least one winter, and there was great danger of losing them if timber centering of the ordinary type were used.
(3)—The three-hinged arch is a statically determinate structure, and it was a simple matter to compute the exact stresses and deflections for each position of the load.
(4)—The deflection of the hinged arch under load was found to be far less than that of centers of the truss or beam type.

As the use of steel centers for the construction of permanent masonry arches of such long span had never been tried before, the latter was an essential consideration. As far as the writer is aware, these were the first steel centers to be used for any but very short spans. The steel centers used in the construction of the 150-ft. arches of the Delaware River Bridge of the Delaware, Lackawanna and Western Ry.† were designed some months later, when the centers described herein were well under way in the shop.

that the observed and computed deflections correspond precisely, and they would not have done so had not assumption as to the distribution of the load been correct. The bows were simply laid on the cross-beams, ing left free to move longitudinally thereon, and carefully framed with butt joints, so as to act as ribs.

The design was computed on the assumption that arch ring would be concreted in 15-ft. transverse tions, or voussoirs, and it was assumed that a s on one side of the arch might be completed in ad of the corresponding section on the other side. It also assumed that the placing of the voussoirs take place in any order, symmetrically about the ce Before checking, however, the order of loading been determined, and the computations were based the assumption of such order of loading.

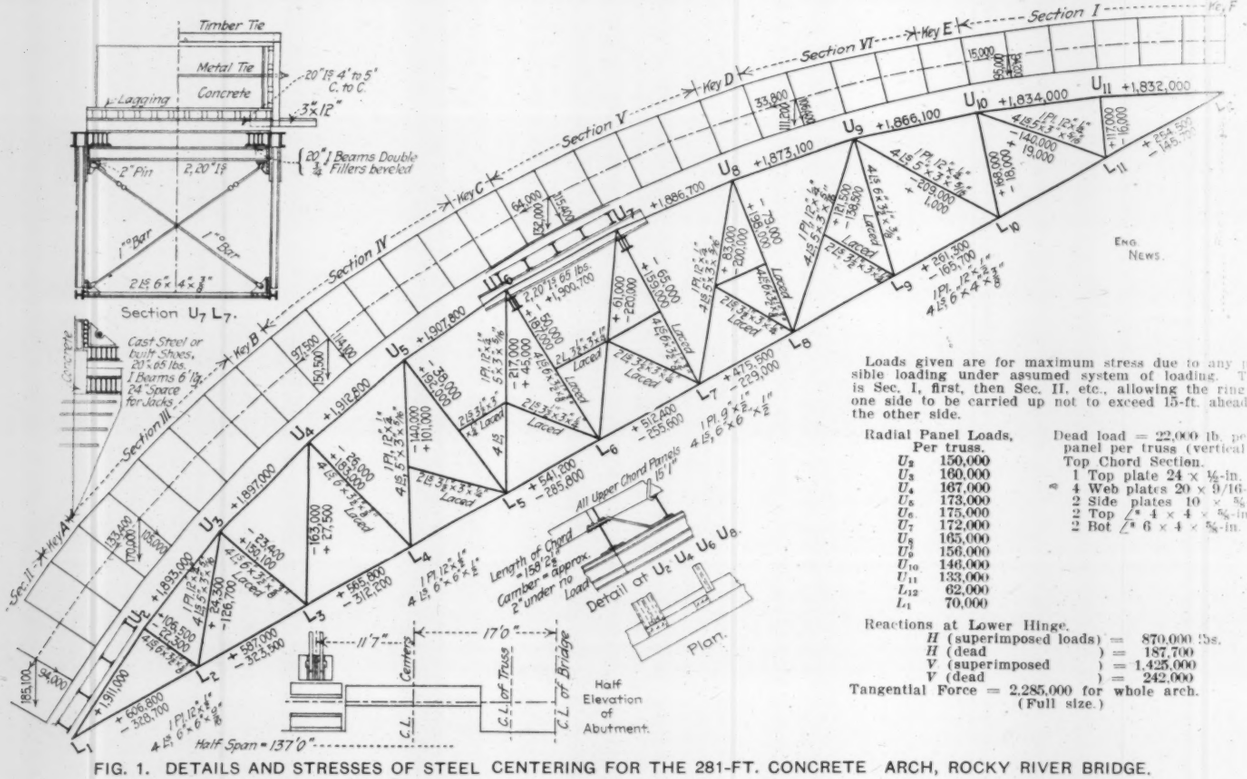
A unit stress of 21,000 lbs. per sq. in. on med open-hearth steel was used, making the proper re tion for columns according to Gordon's formula for connected columns.

It was decided to use bolts instead of rivets fo field connections, in order to facilitate removal, the completion of the work.

These bolts were turned to a diameter of 29/32 and placed in 15/16-in. reamed holes. All hol field connections were reamed in the field, using matic reamers.

The centers were designed to be erected in an a imately vertical position, and then lowered into p from the banks. The contractor, however, pre to erect them on light timber falsework, which w be removed as soon as the trusses were in place. An 800-ft. cableway, installed for handling the con was also utilized in erecting the centers, and in removal.

The weight of steel in these centers was approx 400 tons, of which about 160 tons were steel I-beams which were used in the completed structure, being



Loads given are for maximum stress due to any possible loading under assumed system of loading. That is Sec. I, first, then Sec. II, etc., allowing the ring on one side to be carried up not to exceed 15-ft. ahead of the other side.

Radial Panel Loads, Per truss.	
U_2	150,000
U_3	160,000
U_4	167,000
U_5	173,000
U_6	175,000
U_7	172,000
U_8	165,000
U_9	156,000
U_{10}	146,000
U_{11}	133,000
L_{12}	62,000
L_1	70,000

Dead load = 22,000 lb. per panel per truss (vertical).
Top Chord Section.
1 Top plate 24 × ½-in.
4 Web plates 20 × 9/16-in.
2 Side plates 10 × ⅝-in.
2 Top ∠s 4 × 4 × ⅝-in.
2 Bot ∠s 6 × 4 × ⅝-in.

Reactions at Lower Hinge.
H (superimposed loads) = 870,000 lbs.
H (dead) = 187,700
V (superimposed) = 1,425,000
V (dead) = 242,000
Tangential Force = 2,285,000 for whole arch.
(Full size.)

FIG. 1. DETAILS AND STRESSES OF STEEL CENTERING FOR THE 281-FT. CONCRETE ARCH, ROCKY RIVER BRIDGE.

In computing the stresses, it was assumed that only the radial component of the weight of each voussoir was to be carried by the steel centers, and that the tangential component would be carried by the timber bows, or by reinforced-concrete struts placed in the key sections.

In carrying out the work, both of these provisions were made, the bows being of sufficient strength to carry the entire tangential components of the loads, and reinforced-concrete struts being also provided.

This assumption has been criticised, and the best proof of its accuracy which the writer can offer is the fact

placed across the opening between the two arch-ribs transversely to the axis of the bridge, and encased in concrete.

The use of so large a part of the steel in the permanent structure was quite an item contributing to the remarkable economy of these centers. The cost was approximately as follows:

Material and fabrication	$20,000	
Freight and erection	5,500	
Dismantling	1,200	
Total		$26,700
Value of steel I-beams used in permanent structure	$7,000	
Value of remainder of structure as scrap material	2,500	
		9,500
Net cost of centers		$17,200

*Steel Centering Used in the Construction of the Rocky River Bridge, Cleveland, Ohio. Paper by Wilbur J. Watson, M. Am. Soc. C. E. Proceedings, Am. Soc. C. E., April 1, 1911; p. 507. Presented to the Society June 7, 1911.

†Engineering News, Dec. 30, 1909, p. 713.

The above figures, exclusive of wedges, take no account of overhead or engineering charges, nor the cost of timbering, lagging and moving the centers, the latter being a small item.

The most troublesome problems to be solved were the provision for motion of the steel arches, due to temperature changes, and the design of the lowering [illegible].

The County Engineer's specifications provided that the concreting contemplated therein should be kept up during the construction of the keys, and the writer's intention was to keep the steel centers wet during concreting and setting up of the last key (as shown). As city water would be used, and at fairly constant temperature as it emerged from the hose, it would seem that by this means, and by the use of canvas to screen the steel from the direct rays of the sun, the position of the crown hinge might be kept at a constant elevation for the length of time necessary for the concrete in the key to harden.

It was decided, however, that this was unnecessary, as the arch was not reinforced, and any rise of the center hinge would only serve to open up the voussoir joint at the crown.

This voussoir, therefore, was concreted on a cool day, and the surfaces of the two adjacent arch sections were oiled in order to prevent an immediate bond, so that there would be no danger of the key concrete being prematurely loaded; and the joint at the crown was allowed to open and close with temperature changes. The opening was as great as 5/16-in. at one time. The rise and fall of the center hinge was so sensitive to changes of temperature, that Mr. Stevens, the Resident Engineer, states that he could determine the temperature of the air by measuring the opening.

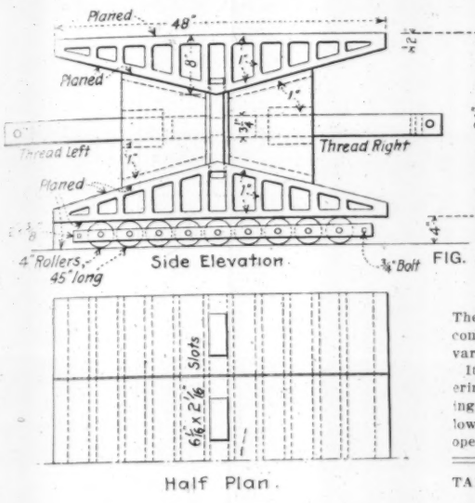


FIG. 2. LOWERING WEDGES FOR CENTERS OF ROCKY RIVER BRIDGES.

The computed deflection of each truss, or half arch, under full load was 2 in., and the trusses were cambered this amount. The observed deflection corresponded with this precisely. It is evident that, in the case of a reinforced arch, it would have been necessary to carry out the original intention of wetting down the centers, but it is difficult to see how the principle of reinforcing an arch of this kind can be defended, because the live load is practically negligible in comparison with the dead load, and the curve of the arch can be adapted to the curve of the equilibrium polygon, thus practically eliminating all bending and shearing forces in the arch ring.

Fig. 1 shows the stress sheet for one-half of one center, and details of the bows, lagging, etc. It will be noted that the arch ring is divided into voussoirs, which are given Roman numerals corresponding to the sequence of concreting. The keys are designated by letters, also corresponding to the sequence in which they were concreted.

It was found by experiment that a concrete composed of one part Portland cement, one part sand, and two parts stone would attain as great a strength in 7 days as the concrete used in the arch ring would attain in 30 days. The rich mix, therefore, was used in the keys, in order that the centers might be the sooner removed.

Tables I. and II. give the observed deflections of the steel arch under different conditions of loading.

The rise and fall of the centers due to changes of temperature were very carefully noted, both before and after loading, as were also the deflections due to partial loadings.

The first concrete in the main arch rib was placed on Aug. 6, 1909, and the voussoirs were completed Aug. 30. The keys were run on Sept. 3 to 9, and the centers were struck on Sept. 28. When the centers were moved into position for the second rib, the first arch rib and the columns, up to the springing line of the spandrel arches, were in place.

The unit stress in the arch rib due to its own weight is about 245 lbs. per sq. in. The settlement of the crown when the centers were removed amounted to 0.038 ft.

The curve of the intrados, as constructed, varies from the computed curve less than ½-in. at the point of maximum variation.

It was at first intended to use hydraulic jacks for lowering the centers, and a plan was worked out for lowering, using 32 jacks, in nests of four, each jack having a lowering capacity of 105 tons; nests of eight were to be operated by a single pump and reservoir.

As it would be necessary to lock these jacks, owing to the length of time that they would be called on to sustain their load in one position, a special locking device was designed which could be released without lifting the ram.

In addition to the hydraulic jacks, the use of sand-boxes, screw-wedges, and screw-jacks was investigated. It was found that the sand-boxes were a little cheaper than any of the other devices, but, owing to the fact that these boxes would be immersed in water (as their position was below mean water level), it was thought that it would be practically impossible to keep the sand dry. The sand-boxes as contemplated, were to be of cast steel, and the estimated cost was but little less than that of the double-acting screw-wedges, which were finally adopted.

The design of these double-acting steel wedges, as finally used, Fig. 2, was suggested by A. M. Felgate, County Bridge Engineer, while looking at the writer's design for a similar single-acting screw-wedge, and appeared to be exactly what was needed. They were made of carefully annealed cast steel, in four sections, planed on all sliding and bearing surfaces, and very carefully adjusted to uniform height when set in position. The motion allowed for was a vertical drop of 6½ ins., and the slopes were calculated so that locking would not be required to hold them under full load. They were lowered by four men on each screw. Each wedge weighed approximately 1,350 lbs.

Next in cost to the steel wedges were the screw-jacks, each of which was designed to lower 105 tons and lift 22 tons. The hydraulic jacks were found to be the most expensive.

Estimated cost of sand-boxes	$1,500
Estimated cost of screw-wedges	1,650
Estimated cost of screw-jacks	2,000
Estimated cost of hydraulic jacks	2,400

Particular attention is called to the high class of shop workmanship required on the centers. The reaming was done with unusual care. The planed joints were required to be perfect, and were the best the writer has ever seen. In fact, the workmanship was better than that required for standard railroad bridge work. In view of this, and also of the fact that the structure was free from impact, the writer is of the opinion that the unit stresses assumed were not unreasonable.

The bridge was built by Cuyahoga County, under the direction of A. B. Lea, former County Engineer, and F. R. Lander, present County Engineer. The structure was designed by A. M. Felgate, County Bridge Engineer. The Contractor was the Schillinger Brothers Co. The Resident Engineer was A. L. Stevens. The centers were built by the Interstate Engineering Co., and the wedges were cast by the Variety Iron Works Co., of Cleveland.

TABLE I.—ELEVATIONS ON ALTERNATE POINTS EACH HALF ARCH TAKEN DURING PLACING OF CONCRETE; ROCKY RIVER BRIDGE.

Date.	Ct. Pin.	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	Temp.	Remarks.
					East Side.			
8/ 6/09	76.819	74.540	66.150	52.315	33.495	10.415	84°	25 tons in place.
8/ 9/09	76.708	74.470	66.150	52.330	33.505	10.410	85°	465 tons in place, Sec. I.
8/11/09	76.683	74.458	66.123	52.308	33.508	10.408	74°	Sec. I and 6 ft. of Sec. II in place.
8/13/09	76.680	74.468	66.106	52.313	33.508	10.403	80°	Sec. II in place.
8/17/09	76.682	74.466	66.106	52.296	33.486	10.391	77°	¾ Sec. III in place.
8/19/09	76.699	74.544	66.109	52.294	33.464	10.384	78°	Sec. III in place.
8/24/09	76.762	74.482	66.102	52.262	33.422	10.367	85°	⅔ Sec. IV in place.
8/26/09	76.782	74.493	66.103	52.233	33.408	10.368	85°	Sec. IV in place.
8/28/09	76.773	74.463	66.038	52.188	33.388	10.358	73°	Sec. V and ½ VI in place.
8/31/09	76.777	74.426	66.006	52.166	33.381	10.351	80°	Voussoirs in place.
					West Side.			
8/ 6/09	....	74.533	66.128	52.328	33.483	10.393	84°	25 tons in place.
8/ 9/09	....	74.455	66.210	52.330	33.490	10.400	85°	465 tons in place, Sec. I.
8/11/09	....	74.428	66.098	52.288	33.478	10.390	74°	Sec. I and abt 6 ft of Sec. II in place
8/13/09	....	74.444	66.181	52.301	33.491	10.396	80°	Sec. II in place.
8/17/09	....	74.429	66.169	52.289	33.469	10.381	77°	¾ Sec. III in place.
8/19/09	....	74.461	66.161	52.281	33.456	10.376	78°	Sec. III in place.
8/24/09	....	74.463	66.078	52.243	33.408	10.363	86°	⅔ Sec. IV in place.
8/26/09	....	74.453	66.058	52.213	33.388	10.353	85°	Sec. IV finished.
8/28/09	....	74.408	65.988	52.178	33.378	10.348	73°	Sec. V and ½ Sec. VI in place.
8/31/09	....	74.391	66.011	52.171	33.371	10.346	80°	Voussoirs in place.

TABLE II.—ELEVATIONS OF SOUTH CENTER PIN DUE TO CHANGES OF TEMPERATURE AFTER CONCRETE WAS PLACED; ROCKY RIVER BRIDGE.

Date.	Hour.	Elev.	Temperature. In shade.	Temperature. In sun.	Remarks.
9/ 9/09	1.00 p. m.	76.771	75°	...	Cloudy.
9/ 9/09	5.35 p. m.	76.758	68°	...	Raining. Key finished at 7 p. m. Temp., 65°.
9/10/09	8.30 a. m.	76.743	69°	...	Trans. reading same as 7.00 last night when key finished.
9/10/09	12.30 p. m.	76.762	74°	78°	Trans. reading same as last night and this a. m. Sun since 10.30.
9/10/09	3.00 p. m.	76.761	75°	..	Clear. Trans. reading same as last night and when key completed.
9/11/09	8.45 a. m.	76.754	69°	81°	Clear. Trans. reading same as last night and when key completed.
9/11/09	11.30 a. m.	76.754	71°	78°	Clear. Trans. reading same as last night and when key completed.
9/13/09	8.40 a. m.	76.770	79°	86°	Clear. Joint open W. side of key, 1/16-in.
9/13/09	1.00 p. m.	76.785	85°	96°	Clear. Joint open 1/4-in.
9/13/09	4.00 p. m.	76.783	85°	87°	Clear. Joint open 3/16-in.
9/14/09	8.35 a. m.	76.770	84°	100°	Clear. Joint open 3/16-in.
9/14/09	1.45 p. m.	76.786	85°	93°	Clear. Joint open 1/4-in.
9/14/09	4.10 p. m.	76.782	82°	85°	Clear. Joint open 1/4-in.
9/15/09	9.00 a. m.	76.764	75°	78°	Clear. Joint open 1/16-in.
9/15/09	12.45 p. m.	76.764	81°	....	Cloudy. Joint open 1/8-in.
9/15/09	4.00 p. m.	76.755	69°	....	Cloudy. Joint open 1/16-in.
9/16/09	9.00 a. m.	76.749	69°	....	Cloudy. Joint open 1/32-in.
9/16/09	1.00 p. m.	76.752	67°	78°	Joint open, 1/32-in.
9/16/09	4.00 p. m.	76.754	67°	75°	" " 1/32 "
9/17/09	9.00 a. m.	76.739	69°	78°	" " 0 "
9/17/09	1.05 p. m.	76.759	71°	82°	" " 0 "
9/17/09	4.00 p. m.	76.758	71°	80°	" " 1/16 "
9/18/09	8.55 a. m.	76.748	67°	85°	" " 0 "
9/18/09	11.50 a. m.	76.751	67°	83°	" " 1/32 "
9/20/09	8.50 a. m.	76.750	77°	82°	" " 1/16 "
9/20/09	4.00 p. m.	76.780	80°	85°	" " 1/8 "

THE POWERS AND DUTIES OF THE ILLINOIS Board of Railroad and Warehouse Commissioners are materially enlarged by an act passed by the legislature of that state and, which it is understood, will without question be approved by the Governor. The act extends the jurisdiction of the commissioners to cover common carriers of every description, including sleeping car companies, express companies and steamboat lines, but excluding teaming companies and also "street railroads, hack lines and vehicles of a light character." Salaries of the commissioners are made $6,000 per year for the chairman, $4,000 per year for the other members and $3,500 for the secretary. Commissioners are authorized "to appoint such other persons and employees as are necessary," etc., but no specific mention seems to be made of engineers. The act appears to give the commissioners substantially all the powers in the way of compelling reports of yearly operations and of accidents, and control over rates, as are now vested in public utility commissions of other progressive states, except that it does not seem to give control over the issue of stocks and bonds.

The "Ransome Unit System"; A Separately-Molded Reinforced-Concrete Construction.

By ALEXIS SAURBREY.*

Unit systems of reinforced concrete find their justification in the greatly reduced amount of falsework required as compared with the monolithic type. Further, it is believed by many engineers that inspection of the finished pieces before erection is the only reliable safeguard against occasional failures, and all engineers agree that field inspection of reinforced-concrete work under present conditions is a very onerous and difficult matter. For these reasons, there has been devised a system of reinforced-concrete construction in which all of the various members are cast separately in a casting yard and set into place in the structure as independent pieces, linked together by interlocking steel reinforcement covered with the concrete slab poured in place. One development of this system has been devised and patented by Ernest L. Ransome and has been termed the "Ransome Unit System." Recently its effectiveness has been demonstrated by the completion of a four-story building, 60 × 200 ft. in plan, for the United Shoe Machinery Co. at Beverly, Mass, and further established during the progress of the additional buildings now being erected for the same company. A short description of the methods used and the design of this kind of work may therefore be of interest.

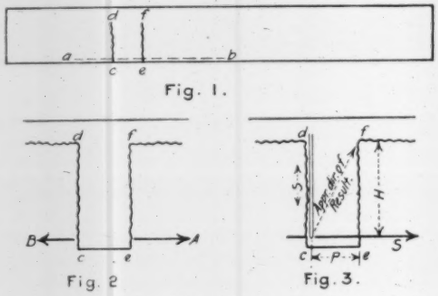


Fig. 1. Fig. 2. Fig. 3.

Figs. 1 to 3.

The greatest difficulty in the economical construction of "unit" work arises from the fact that it becomes necessary to make special provision for the compressive area in beam or girder, while in the monolithic construction, the slab provides the necessary compressive area. The "Ransome Unit System" is based upon the ideal that it is possible so to unite the slab and beam that they may be considered as working as a unit.

In the latest development of the method the U-bars have been designed with a view toward creating the required tie between the previously erected beam and the slab which latter is molded on the ground.

This particular feature of the new method of construction is in direct contradiction to accepted theories; in fact, the usual specification calls for "all beams and girders to be molded in one monolithic piece with the slab directly above same"—or similar words. In the writer's opinion, this particular specification is of great importance in all cases where the U-bars have been designed according to the old-fashioned shear theory; in the more modern methods, where the U-bars are considered as acting in tension only, this objection vanishes entirely. Let, in Fig. 1, the dotted line *ab* represent a section of the reinforcement of a reinforced-concrete beam, let, further, *cd* and *ef* represent two vertical cracks such as have been observed by Turneaure, Mörsch, and many others; let, further, the stress in the steel increase to its working load, where we know that many such cracks exist, as their first appearance is noted under stresses as low as 4,000 to 6,000 lbs. per sq. in. In Fig. 2, the portion *cdef* is again reproduced in larger scale, and the small concrete body *cdef* now appears as a kind of cantilever beam attached to the upper portion of the beam along the line *df*, and loaded at its extremity *e* with a force *A* pulling to the right and at *c* with another force *B* pulling to the left. The actual load on the cantilever will be the difference between *A* and *B*, and assuming *A* to be the larger, the resultant force will be *S*=*A*—*B* pulling to the right as shown in Fig. 3. This produces a bending moment $M = S\,H$, where H must be approximately equal to, but always smaller than, the distance from the steel to the neutral axis, hence the stress in the U-bar *cd* becomes approximately

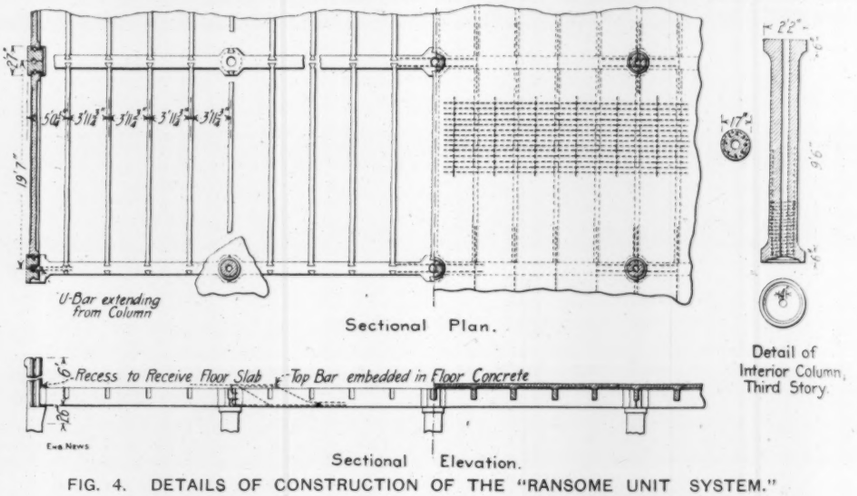
$s = S\,H \div P$, where P represents a distance approximately equal to the distance between cracks, but always somewhat smaller than that distance. This may be written

$$\frac{s}{S} = \frac{H}{P}$$

so that the resultant of s and S always passes near the point f of Fig. 3. If now the U-bar is so well anchored into the upper slab, and around the main tension bar below, that no sliding of the U-bar can take place, in its own direction, then there can be no failure of the system by sliding along the structural joint *df* when the angle *dcf* is so small that the angle of friction between the stem and the slab is not exceeded. Hence the spacing of the U-bars is determined by the angle of friction between concrete and concrete, molded against one another, which angle is presumably in the vicinity of 41°, so that if the U-bars are spaced less than the distance H, there is no danger of sliding between slab and stem. The further calculation of the size of the U-bars would carry us too far if we went into the details, although they are very simple; suffice it to say that the calculations finally dissolve themselves into precisely the same as used for the diagonals and verticals of a truss; the U-bar representing the verticals and the compression stress in each concrete cantilever representing the diagonal in a Howe truss. In making these calculations, due allowance must be made for the influence of the bent bars of the member if any such bars are used, as will frequently be the case.

A recent patent, granted to Mr. Ransome, provides for the further details of construction, the main details of which are shown in Fig. 4.* The previously-molded columns are erected on their footings, and set dry, while the grouting is done from the top after the setting of the girders and beams. For this purpose, the columns have a longitudinal hole terminating in a wider cavity at the bottom which receives the grout which is poured from above. The general principle of construction is to set all pieces dry in so far as possible, seal the joints with dry mortar, or fairly dry mortar, and then pour the grout which finally unites the several pieces together. The columns may of course be made of any cross-section, but the round and the octagon shapes are best adapted for factory purposes, and the reinforcement is then naturally of the "hooped" type. It is, however, necessary to enlarge the caps and bases of the columns so that, at these points, the concrete will be able to transfer the weights. The reason for this is that it has been found impossible to make the main column reinforcement continuous from story to story; however, the continuity obtained at these points in the various types of construction is more imaginary than real in most cases, and it is just as well to dispense with the uncertainty of these joints, which have always been justly considered as one of the weak points in reinforced-concrete construction. Instead, the unity of construction is obtained by means of longitudinal rods extending through the central core of the column. These rods are bedded in the grout poured into the central hole, as described above, and prevent any relative movement of the columns above and below, if indeed any such movement could take place.

On top of the columns the main girders are placed, the ends of each girder being enlarged so as to cover the cap of the column entirely with a margin of one or two inches. The girders have pockets into which the beams fit loosely with their dove-tailed ends. The tops of beams and girders project above the upper face of the concrete, and the bent-up bars of all members also project above the concrete. Thus, when the slab is finally poured, the compressive function of the slab is ensured according to the principle described above. But the projection of the tension bars above the body of the beams or girders also makes it possible to tie the various elements of construction together in a manner similar to that used in several types of monolithic construction, by means of individual top bars placed alongside of the upper portions of the main tension bars. If desired, the bars may be laced or tied together, but for ordinary construction the simple juxtaposition of the rods accomplishes all that is necessary. Of course, the larger the body of concrete surrounding these bars, the firmer their connection, and for this and other reasons the previously-molded members are made as high as up to the approximate position of the neutral axis. The thickness of the slab itself will usually run considerably less than what would be required to bring the bottom of the slab down to the neutral axis, and so the beams and girders are joined to the slab with a bevelled joint, giving a slight draft to the forms, increasing the strength of the joint, and affording a sufficiency of concrete around the joining bars to develop the required grip of concrete around steel.


U-Bar extending from Column
Sectional Plan.
Recess to Receive Floor Slab
Top Bar embedded in Floor Concrete
Sectional Elevation.
Detail of Interior Column, Third Story.
FIG. 4. DETAILS OF CONSTRUCTION OF THE "RANSOME UNIT SYSTEM."

In the buildings constructed so far, the beams have been spaced about 4 ft. apart, and even for heavy factory floors a slab thickness of 5½ ins. inclusive of the finish coat, has been found amply sufficient. The slab is molded on wooden or metal panels resting with their edges on 3 × 6-in. wooden stringers; the stringers are fastened to the beams by means of bolts. The

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*These drawings are not those used for the Beverly work, which differs from that shown in several particulars, especially as to the method of tying adjacent members together.

several concrete pieces are placed by means of a stiff-leg derrick; as shown in Fig. 6, the derrick picks up four or six beams at a time and drops them quickly and neatly in position. The wooden slab forms are handled by the derrick, a gang of "two-man size" a couple of helpers and a gang of rough men have them in position in short order. The derrick is also used for concreting columns, for which purpose one-yard buckets have been found convenient. One derrick will easily set all the exterior and interior columns, girders, beams and slab forms for a space 30 × 60 ft. in less than a day, leaving time enough for concreting the floor slab of the same panel. For an engineer used to the customary forest of shores and timbers under the floor, and large gangs of wheelbarrow and spade men on top of the floor, it is quite a revelation to see the smoothness and comparative ease with which a floor of this kind is put up. The labor is essentially skilled labor as compared with that used on older types of construction, and much of the objectionable has been eliminated with the gang of "rough" labor. As the slabs carry nothing but their own weight under the dead weight, they may safely be stripped in two or three days after concreting, when the weather is fairly warm.

FIG. 5. CASTING YARD AT THE BUILDING OF THE UNITED SHOE MACHINERY CO.
(Showing also some columns cast in place.)

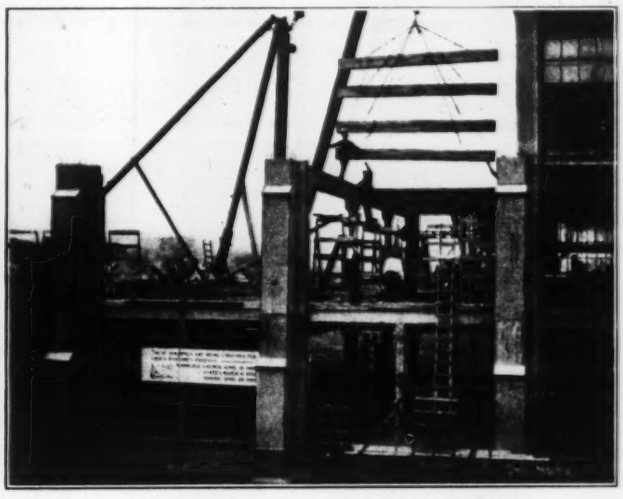


FIG. 6. DERRICK HANDLING FOUR BEAMS AT ONE TIME.

The absence of all shoring underneath the floor makes it imperative that the beams and girders be designed strong enough to carry their own weight plus that of forms and wet concrete slabs, in addition to an allowance for impact from buckets and so forth. But on account of the really excellent workmanship obtained on the elements cast on the ground and under favorable conditions, it seems reasonable to allow somewhat higher concrete stresses for this particular type of loading; for a mixture 1:2:4, and for units 3 to 4 weeks old, 800 to 1,000 lbs. per sq. in. might probably be allowed without trouble. But in the majority of cases the stresses need not reach even this intensity, depending upon the conditions of the lay-out and the estimated loads.

There is, of course, a number of objections which at once present themselves to the uninitiated. The writer has made it a point to verify if possible the accuracy of the work on the buildings at Beverly, Mass., and it must be admitted that the error in measurements is very small, in no case exceeding ½-in. The columns above appear to be set exactly on top of those below, and all the columns line up to perfection as far as can be detected with the naked eye. It is impossible to avoid noticing the freedom from bulging and sagging beams and girders, and the neat and true appearance of the work. The writer knows from experience that great pains were taken with the buildings erected in 1907 of similar general design, but erected according to the old method; yet it is impossible wholly to avoid defective forms and yielding supports, and the new method certainly gives better results owing to freedom from such defects. It has frequently been stated that cores such as used for the columns could not be withdrawn; they are 6 ins. in diameter at the top, 4 ins. at the bottom, and when taken out at the proper time, when the concrete is fairly set, they come up without trouble. The core used at Beverly is made of wood and covered with sheet iron; the cores are usually pulled by means of the locomotive derrick used for handling the forms on the ground when it comes by. It takes about one minute to pull a core. Other objections have solved themselves in similar manner, and the finished work is in itself the best evidence of the soundness of the plan and the efficiency of the means for carrying it out. The test loading of the finished structure has given very satisfactory results, and in spite of the heavy machinery revolving at great speed, the vibrations are not noticeable.

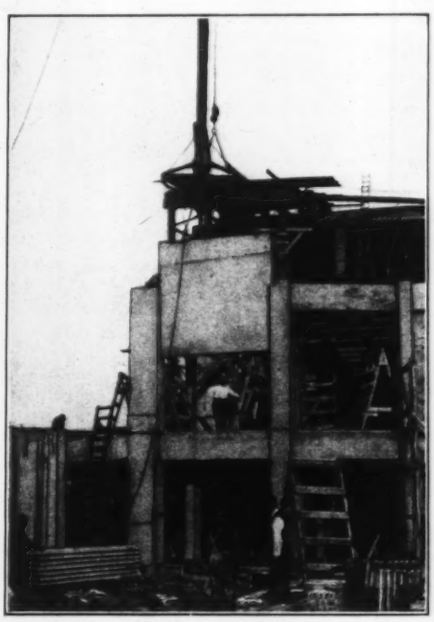


Fig. 7. Setting a Wall Slab in Place, United Shoe Machinery Co., Beverly, Mass.

The concrete plant used at Beverly includes an inclined railway for bringing the materials to the mixer hoppers, and another inclined railway for delivering the concrete to the overhead hopper from which it is drawn into buckets placed on a flat car running on an ordinary industrial track. This arrangement was necessitated by the location of the various buildings to be handled from the same central mixing plant, and would not be duplicated where only one building was to be erected; in that case, the mixer would discharge directly into a hopper over the industrial track. This track runs parallel with the building to be erected, serving both the building and the casting yard; the latter is equipped with a locomotive crane handling the concrete buckets for filling the molds for the units, and which also handles the molds, etc. The stiff-leg derrick receives the units from the locomotive crane, and sets them in place, and also serves for handling the slab molds, as well as for concreting the floor.

In regard to the cost of construction, it may be stated in general that the usually very large investment in lumber is greatly reduced. In fact, four forms of each kind for columns, curtain walls, and girders will be sufficient for a building 400 ft. long × 60 ft. wide, and the beams are cast in gang molds accommodating some 20 beams at a time. All of these forms are set up exactly the same total number of times as for the old type of monolithic construction, but on the ground instead of in the space, eliminating much of the difficulty, and of course, all the shoring. The stability of tall forms for columns and similar pieces may be ensured by nesting the forms, casting four columns together in a gang mold. The only forms which have to be left in place permanently for any length of time are the bottoms on which the pieces are cast; usually 10 days are allowed to lapse before the units are moved. It is a matter of common knowledge that about 60% of the original investment in lumber on the monolithic type is a total loss, and it is only by the most expert design of the forms, and the most careful handling that this figure can be appreciably reduced. In the new type of construction, the loss is reduced to a minimum, and the original investment is very much less.

The concrete units may be lifted in place at a cost as low as 46 cts. per ton; the average cost of several weeks work was, however, $1.17, which includes handling in the yard and setting only. The low figure was obtained on May 26, when 81 pieces of a total weight of 66 tons were set for $30.21, and has been duplicated several times since. The additional cost of grouting the joints averages about 1 ct. per square foot of floor surface. This figure evidently would be materially reduced for a building of simpler architectural design, as many curves and offsets in the buildings under consideration require extra precautions in setting. It should be the aim of the designer to have as few and as heavy pieces as possible, always keeping within the capacity of the derrick (say 5 tons) but on the Beverly work, the lay-out

of the machinery transmissions required an extra set of bridge beams which might ordinarily be dispensed with. It will be noted from Fig. 5 that the very large flue-columns are cast in place, as they exceed the capacity of the derrick considerably.

The principal requirements on construction of this kind are good plans and careful field engineering, coupled with intelligent handling of the forces in the field. It is admitted that these requirements are the same as for the monolithic type, but on account of the higher type of men employed, and the much smaller number, the management becomes less of a burden. In fact, if scientific management has any possibilities as applied to field engineering, this is one of the places where it is best adapted and will give the best results, as no other forms of contracting approaches so much to the routine and permanency of form as this.

The cost of work done so far compares very favorably with that of the older buildings in spite of the general advance in cost of labor and materials. It may be stated that a saving of at least 10% is easily obtained, and it may in some cases run as high as 25%.

The "Unit System" of Separately-Molded Reinforced-Concrete Members as Applied to a Large Factory Building.

A system of reinforced-concrete construction which has been developed in the past few years employs separately-molded members which are erected in the usual way, provision being made for concreting the connections so that the completed structure is as rigid as one built under the monolithic method. The reinforcing bars in the members project at the connections and are embedded in concrete placed after assemblage, so that the reinforcing system becomes practically continuous (as in a monolithic structure) instead of being independent in each part. The amount of concrete deposited in place is only about 2 or 3% of the total amount, or of the amount which would be deposited in place under the monolithic system of construction. Individual members may be inspected or tested, as in steel construction.

A partial section and elevation of a building constructed under this system, which is controlled by the Unit Construction Co., are given in Fig. 1, and show the principle of construction. This is the oxide mill of the National Lead Co., at St. Louis, Mo., It is a five-story building about 100 × 122 × 93 ft. in plan. Some of the typical members are shown in Figs. 2, 3 and 4.

The columns, Fig. 2, are provided with brackets for the support of the girders. The steel rods for reverse movement in the girders, project into the space over the column bracket, the girders being cut back as to expose the steel sufficiently to give the necessary length for embedment. This is shown in Fig. 3, and the projecting rods of two contiguous girders are so arranged as to overlap. The floor slabs (Fig. 4) consist in general of a thin plate strengthened on the four sides by a heavy rib and having a central rib also. These ribs rest on shelves or ledges on the sides of the girders (Fig. 3), the arrangement being such as to bring the top of the slab above the top of the girders. The slabs are not placed in close contact, but with open joints to receive cement grout. The outer face of each side rib has a groove, so that the two grooves of adjacent slabs will form a key for the grout filling. On the first floor of one of the buildings the slabs are designed for a load of 500 lbs. per sq. ft. The slab is 3 ins. thick, but the depth over ribs is 17 ins. and the ribs are thicker than in the slabs shown in Fig. 4.

The reinforcing rods project from the sides of the floor slab into the space above the girder, and the rods of two adjacent slabs overlap in this space. When the spaces at the ends of the girders and between the floor slabs are filled with concrete, a very rigid construction results. The roof construction is similar to that of the floors. The wall slabs are fitted to grooves in the columns and then grouted in place; the slab has a groove in each edge to form both a key and a passage for the grout. In this type of building the strength is in the structural framework, and the wall slabs form simply a filling or curtain. Where it is desirable to connect the walls structurally with the columns, the latter are made with slots to receive bars which extend through the columns between the joints with the slabs.

In placing the field concrete to connect the unit members no attempt is made to form a complete bond with the concrete of these members; the field (or grout) concrete is used either in direct shear or in compression, or as a means for bonding the projecting and lapping bars in the space between the units. The exposed surfaces of the units are cleansed thoroughly and soaked with water before the grout concrete is placed.

The erection of the members is done in many cases by means of a locomotive crane. For the stack building of the National Lead Co.'s plant (noted below) there was used a stiff-leg derrick with a 60-ft. boom, mounted on a traveler about 50 ft. high. The traveler backed away from

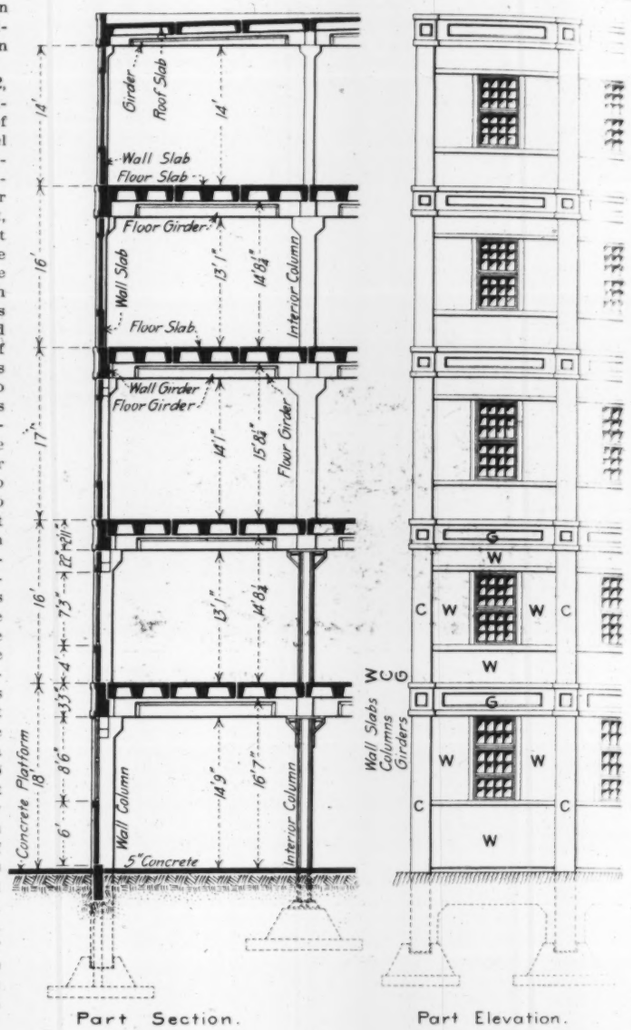


FIG. 1. PART ELEVATION AND SECTION OF BUILDING ON THE "UNIT SYSTEM" OF REINFORCED-CONCRETE CONSTRUCTION (OXIDE MILL OF THE NATIONAL LEAD CO., AT ST. LOUIS, MO.).

(Unit Construction Co., St. Louis, Mo.; Designers and Builders.)

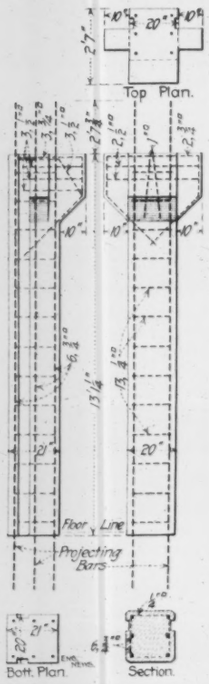


Fig. 2. Details of Column Construction.

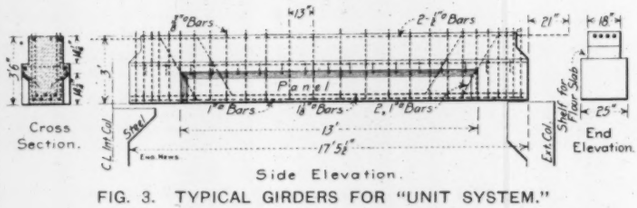


FIG. 3. TYPICAL GIRDERS FOR "UNIT SYSTEM."

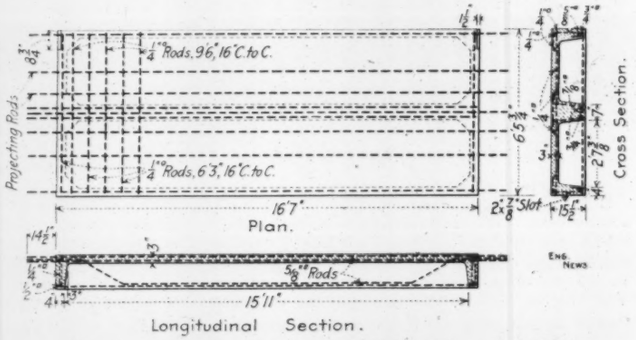


FIG. 4. TYPICAL FLOOR SLAB FOR "UNIT SYSTEM."

the work as the erection progressed. The erection of the building is shown in Figs. 5 and 6. In Fig. 5 a girder is being set in place on the column brackets, and the rods may be seen projecting from its ends. In Fig. 6, a wall slab is being lowered into place, sliding in the grooves in the faces of the columns. The vertical rods may be seen, projecting from the tops of the columns.

Buildings erected on this system include the ... a 15-stall roundhouse at Waukegan, ... the Elgin, Joliet & Eastern Ry.; a grain elevator, of 15,000 bushels capacity, at Highland, Ill., for the Highland Milling Co.; a warehouse at Chicago for the Universal Portland Cement Co.; also buildings for the Search Light Gas Co., at Chicago, and the Ohio Cultivator Co. at Bellevue, Ohio. Buildings for the National Lead Co. include a warehouse at Kansas City, annealing house at Granite City, corroding stacks at Chicago, a building now under construction at New Kensington, Pa., and several structures at St. Louis. The work now being done at the plant of the National Lead Co. at St. Louis, Mo. (Sublette and Manchester Aves.) includes six buildings; stack building (105 × 750 ft., and 50 ft. high), oxide mill, machine shop, oil mill, office building and welfare house, and a stable and automobile shed. The stack building is divided into 82 bins or "stacks" 19 × 43 ft., and about 30 ft. high; these open upon a 16-ft. aisle or passageway. A telfer system operates in this aisle and above the stacks, and serves for the handling of lead and tanbark. The stacks are filled with alternate layers of these materials, and the maximum lateral pressure at the bottom is estimated at about 125 lbs. per sq. ft. This building has no windows or other side openings except those required for the telfer system, light and ventilation being provided for by skylights and louvres in the roof. As the corroding process evolves corrosive gases, these louvres and skylights are made entirely of reinforced concrete glazed with wire-glass. The down spouts are the only sheet metal work on the building. In the smaller buildings, the exterior columns were cast the full height, the interior columns being spliced at the second-floor level.

As this St. Louis work involved about 20,000 cu. yds. of concrete, considerable attention was given to the arrangement of the mixing plant and casting yard. Sand and gravel are dumped from hopper-bottom cars into a pit beneath a railway track, and raised by an inclined bucket conveyor to overhead bins of about 200 cu. yds. capacity. The mixer is directly beneath the bins, and is fed from them, the sand and gravel being measured in a hopper above it. The cement is stored in a shed adjacent to the railway track, and is carried by small push cars to the mixer, where an elevator raises it to the proper level for charging. The mixer discharges the concrete into ½-yd. steel dump cars operating on a cable tramway. This tramway is on a trestle about 16 ft. high, extending along the casting yard. It has a circuit of about 1,200 ft., consisting of two parallel lines connected by semi-circular curves. The cars dump into portable chutes which deliver the concrete directly into the forms for the units or members, which are arranged in a row on either side of the trestle. In Fig. 7 is shown a load of concrete being delivered to a form, with the empty car moving away from the chute.

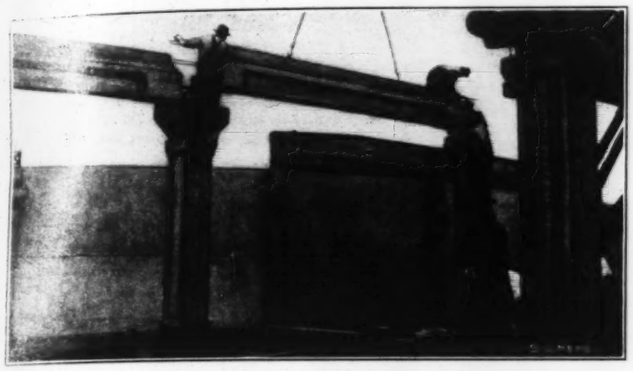


FIG. 5. SETTING A CONCRETE GIRDER IN PLACE ON THE CONCRETE COLUMN.
(Stack Building of National Lead Co., at St. Louis, Mo.)

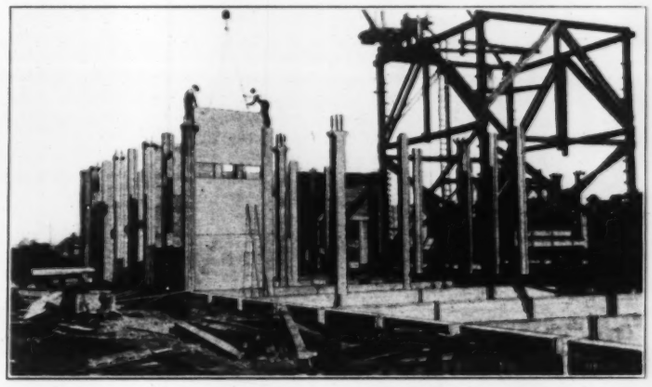


FIG. 6. SETTING A CONCRETE WALL SLAB IN PLACE IN THE GROOVES OF THE COLUMNS.

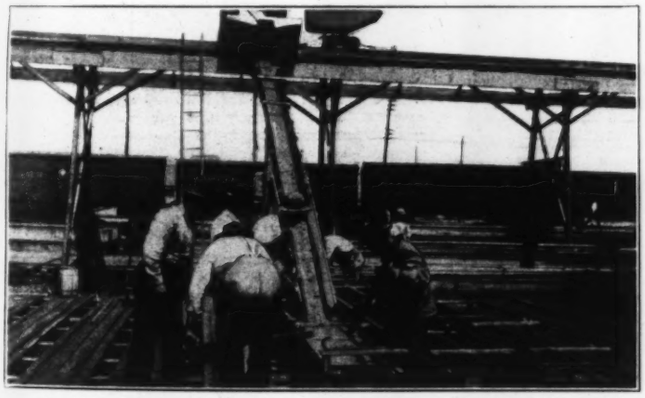


FIG. 7. DUMPING CONCRETE INTO FORMS FOR UNIT MEMBERS.
(The ½-yd. dump car is operated by a cable on the trestle.)

The amount of yard room required for any particular work is determined by the size or extent of the work, by the time in which it must be completed, and by the amount that should be poured daily for economical operation. For this system of construction it is necessary, of course, to prepare a schedule for casting the units (or members) so as to have the proper number on hand ready for erection. The units are removed by a stiff-leg derrick (having a 60-ft. boom), which travels on a track laid on a trestle running lengthwise of the yard; this places them on the ground within reach of a 15-ton locomotive crane (with 50-ft. boom) which serves the buildings, or places them on flat cars for delivery to this crane.

This system of construction, known as the "Unit System," has been developed by J. E. Conzelman, C. D. Morley and Albert J. Meier, who are respectively Chief Engineer, Superintendent of Construction, and Director of the Unit Construction Co., Liggett Building, St. Louis, Mo.

A New Tripping Device for Steam-Shovel Dippers.*

A steam-shovel dipper trip devised by steam-shovel engineer A. H. Geddes of the Central Division of the Panama Canal has been recommended for use on the dippers of 40 of the 95-ton steam shovels. The present trip, or latch, by which the bottom of a steam-shovel dipper is opened to discharge material is operated by a rope in the hand of the steam-shovel craneman, and frequently the force required is excessive. The device invented by Mr. Geddes consists of a steam cylinder whose piston acts through levers to open the latch on the door of the dipper. Steam is admitted and exhausted from the cylinder, which is mounted on the dipper itself, through a three-way valve located on the boom beside the craneman's seat. A steam pipe extends from the valve along the boom as far as the dipper-stick slot and is connected at this point by a universal joint to a flexible hose leading to the cylinder.

At the request of the inventor, his device was given a trial on steam shovel No. 216 at work in Culebra Cut. The cylinder used was one taken from available stock and was not perfectly suited to the work. The test was begun on Jan. 18 and ended on March 31, and in this period the shovel excavated an average of 1,418 cu. yds. a day. In the 60 working days from Oct. 30, 1910, to Jan. 12, 1911, this same steam shovel, working under practically the same conditions, using the old style trip, excavated an average of 939 cu. yds. a day. Six other shovels working under practically the same conditions, using the old style trip, during the period of the test excavated an average of 1,222 cu. yds. a day.

The committee which considered the merits of the device consisted of Major T. C. Dickson, Inspector of Shops; W. H. Bates, Supt. of Steam Shovel Repairs, and Lewis Webster, Steam Shovel Engineer. In its report this committee says:

While the effect of the device upon the amount excavated is based upon the operation of a single shovel, the above data indicate in the opinion of the committee that the device increases the output by at least 100 cu. yds. per working day. Taking the cost of the excavation at 67 cts. a cu. yd., the value of the device would be $67 per day. It is estimated that the device can be made and applied in quantity for about $125 per shovel.

Account was not kept of the actual cost of repairs made to the device, and the committee is of the opinion that the cost of repairs and maintenance of the device will appreciably exceed the corresponding costs with the rope trip, but that the cost of original installation and the cost of running repairs will be small in comparison with the value of the increased output, as estimated above.

The committee recommends its adoption and installation on all dipper sticks of 95-ton shovels on which 4 or 5-yd. dippers are used.

HARBOR IMPROVEMENTS AT PHILADELPHIA.—The Department of Wharves, Docks and Ferries has prepared plans for the improvement of the port which would involve a total expenditure of $25,000,000, the money to be raised by bonds issued as required. Extensive improvements are needed at once to retain and increase the shipping trade. It is proposed to build piers 1,000 to 2,000 ft. long, with stone or concrete walls and solid earth filling; upon these would be warehouses. The U. S. Government, also, is working on the establishment of a deep channel 800 to 1,200 ft. wide in the Delaware River, giving a depth of 35 ft. at low water from the city to Delaware Bay. The above particulars are taken from the fourth annual report of the Department of Wharves, Docks and Ferries, which has been prepared by Mr. Joseph H. Hasskarl, M. Am. Soc. C. E., Acting Director. An account of proposed improvement in the port of Philadelphia appeared in Engineering News of Feb. 16, 1911.

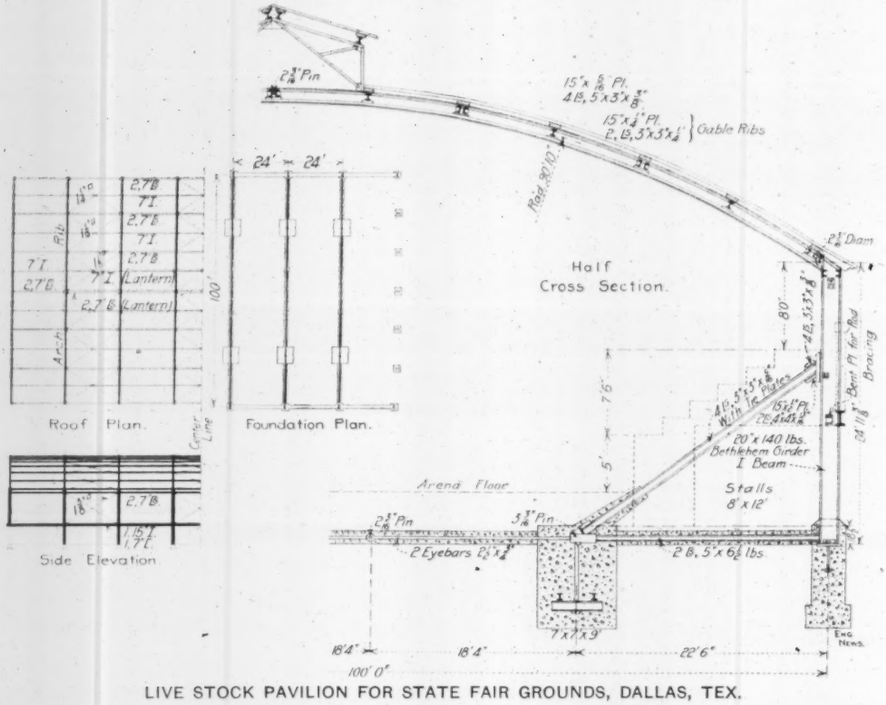
*Abstract of an article in the "Canal Record" of May 3, 1911.

State Fair Live-Stock Building at Dallas, Tex. A Novel Arch Roof and Comparison With a Truss Roof.

By HOWARD E. ARTHUR,* M. Am. Soc. C. E.

The new Live-stock Building now in course of construction on the grounds of the Texas State Fair Association at Dallas, Tex., possesses an unusual feature in a roof construction distinctly different from the types ordinarily employed in buildings of this kind. The roof is carried by steel rib arches, and these arches rest on the tops of side-wall columns; the columns are braced to resist the arch thrust by inclined tie-beams inside the building, anchored down by counterweight concrete. A careful estimate of the weight of this roof shows it to cost about as much as the typical arena style of truss roof.

The arch roof was designed by the writer for this building in January, 1909, but the money originally appropriated for the building was combined with a similar amount raised by the citizens and put into another building, which caused the Live-stock Building to be postponed two years.



LIVE STOCK PAVILION FOR STATE FAIR GROUNDS, DALLAS, TEX.

THE ARCH ROOF.—The main feature of this building is a solid shallow arch rib only 15 ins. deep, with three hinges. The thrust of the arch is taken up by a stiff post acting as a cantilever. This post is a 20-in. 140-lb. Bethlehem girder beam, and is held in equilibrium by an inclined tie connected to the post about two-thirds the height above the base, acting together with a strut between the base of the post and the foot of the inclined tie, where there is a counterweight. These counterweights are made of concrete and each one contains 161⅔ cu. yds. A horizontal tie in the ground, composed of eyebars extending from one counterweight to the other, balances the entire arch thrust at this point.

The other types of frame considered in designing this building were (1) the usual open-web three-hinged arch with spring line hinges at floor level, (2) a simple truss with inclined top chord and curved lower chord, 10 ft. deep at the center, and (3) a three-hinged arch like the one selected, except a bottom chord was contemplated at spring line. The objection to the first was that its form would probably be such that it would be too wide where it cuts through the seats and either compel the public to walk through the web or step down and around it. The simple truss was dismissed as being not sufficiently pleasing to the eye for a public building. The third type was cheaper than the one selected, but the bottom chord was objectionable.

The dead load of the entire roof is about 15 lbs. per sq. ft., and the wind load is very small. The purlins have 24-ft. span and are only 7 ins. deep; they have camber bars about 4 ft. on centers to raise the wood filler so that the roof sheathing will remain level. The foundations all had to go about 9 ft. below surface in order to find good bearing soil; the upper 7 ft. is black waxy soil, very fine for raising four crops per year, but poor for building purposes.

The connection of the inclined tie to the post was made with a ½-in. plate and two 4 × 4-in. angles, care being taken to have the angles thick enough to resist bending in either direction. These angles were riveted to the post with an air hammer instead of the shop squeezer, as the air hammer would not cause heads to grip the metal as tightly, thereby leaving more strength in the heads to resist tension on them. There are 20 ⅞-in. rivets connecting these angles to the post, at an average pull on each head of 2,250 lbs. for dead load only. For a larger span than this, a plate-girder post would be better, as the web could project out and all rivets would be in shear only.

The arch design used here, with a 24-ft. spacing, weighs 1,375 lbs. per lin. ft. of building, or about 13 lbs. per square foot of ground area. The truss design, with 20-ft. spacing, weighs 1,519 lbs. per lin ft., or about 15 lbs. per sq. ft. The steel in the roof weighs 2¼ lbs. per sq. ft. more for the truss design than for the arch. Thus the weight of steel below the purlins is about the same in the two designs. The wind produces much larger strains in the truss than in the arch, though the truss columns are fixed at their bases. The weights of these designs were taken from shop details and are therefore very close to being correct. The additional concrete required by the arch design for counterweights was 32⅔ cu. yds. per panel, and was let for $6 per cu. yd. in place.

The eave of roof in the arch design is only about 8 ft. above the top seats. With the truss roof this space would necessarily have to be 12 ft. higher, which would require 12 ft. additional brickwork all around the building. This brickwork makes the truss plan cost just a little more than the arch design.

The arch roof requires more care in erecting. The first pair of arches will have to be supported every 25 ft. until all bracing is in them. Two gin poles will erect the rest without any other supports. Before raising the ribs one will have to be carefully measured center of pin holes; then they will be up to get the best results, and marks suit, and it may be necessary to put plates at columns to obtain uniformity.

The contract for the building was the Mosher Mfg. Co., of Dallas and Tex., as lowest bidder, the arch design adopted.

*Chief Engineer, Mosher Mfg. Co., Dallas, Tex.

Permanent Survey Monuments for Towns and Cities.*

By RALPH B. SLIPPY.†

In the writer's opinion the following are the of good monuments for cities and towns.

1. They should not be expensive in first cost.
2. They should be easy to place in the correct
3. They should be difficult to move from the position.
4. They should be of durable material.
5. They should be easily identified and describ
6. They should be easy of access.

Various materials have been used for mo The following are probably the most practical.

1. Iron pipes or rods driven into the ground.
2. Iron pipes or rods surrounded by cement.
3. Cast iron stakes of various patterns.
4. Iron pipes with a screw top upon which the is preserved; or the top may unscrew, disc a marker of brass or copper.
5. Solid or reinforced concrete built in plac
6. Solid or reinforced concrete made in the and set in the ground.
7. Cut stones, set on end and bearing a hol or brass plug.
8. Irregular stones set on edge or end, with or without marks.
9. Vitrified clay monuments of various shapes and sizes.

Of these perhaps the cheapest are the iron pipes or rods driven into the ground. They can be made from scrap iron bought of any junk dealer at a low price and are as easily set as an ordinary stake. If driven at least 2 ft. into the ground, they are not easily disturbed by slight accidents although they can be pulled out and redriven easily. They are also so common that they bear no special identification mark and for that reason are not good. However, if surrounded by concrete they will come the nearest to fulfilling all the requirements given above.

Cast-iron stakes are not so satisfactory. They are too easily broken in driving even when a wooden block is used to cushion the blow. When once driven they have all the advantages of iron rods set in concrete.

Iron pipes of specially constructed patterns are good whenever the expense will be justified. The same remarks apply to cut stone monuments.

Solid concrete monuments are not as good as those having the iron rod buried in them. If used it will simply be a question of relative expense in deciding whether to build them in place or to make them in the shop and set them afterward. Irregular shaped stones and vitrified monuments should not be used where there is much danger of disturbance.

Monuments may be placed at the intersection of the center lines of the cross street, at the block corners, or on offset lines. Wherever they are set there is danger of their being removed during the construction of some improvement. If in the roadway, they may be destroyed when pavements, sewers, water, or telephone conduits are put in. If placed at block corners, they may be destroyed when new buildings are erected or when new walks are built.

In residence districts, it is probably better to place them at the block corners although this requires many more monuments. The writer would prefer to place simple iron stakes at all block corners rather than more expensive concrete monuments in the street intersections as the additional number would enable them to be checked up with greater ease. In addition, they can be used for lot surveys with greater facility. In business districts, it is probably better to take references to the permanent buildings and record new references as the old marks one by one become worthless.

The previous remarks have been made with reference to monuments for land lines only. The concrete monuments, if built deep enough to resist the action of frost, will be of great use as bench marks. When lighter monuments are used, it will be well to make a few more substantial ones for bench marks.

Elevations taken on sidewalks, curbs, manholes, hydrants, and even on the water table of brick buildings are more or less uncertain. Perhaps the only safe way to preserve elevations is to run check levels at intervals of a few years.

*From the "Proceedings" of the 23d Annual Meeting of the Iowa Engineering Society.

†Waterloo, Iowa.

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It is generally accepted that cast-iron water pipe of the bell-and-spigot pattern is of better quality when cast with the spigot-end up. When cast in this position, a shrinkage head, which is simply an extension of the pipe at the upper end, can be easily provided. The dirt which may be present in the molten iron when poured will then rise into this shrinkage head, or extension piece, which is subsequently cut off in a lathe. Incidentally a much closer fit at the pipe joints is obtained by turning the spigot to exact size at the same time the extension piece is cut off.

When the pipe is cast with the bell-end up, on the other hand, an effective shrinkage head is scarcely practicable. The dirt in the iron rises in the mold as before but its passage up into the shrinkage head (if any be provided) is obstructed by the flare of the bell. As a result, dirt collects at this point and the pipe is weakest at the very place likely to be the most strained.

Only a prohibitive difference, therefore, between the costs of casting pipe in the two positions would justify the very general American practice of casting with the bell-end up. But that such a difference does not exist is shown by the fact that practically all water pipe is cast socket-end up in European countries and even in Japan. Many different methods of producing pipe in this position are in use, one of which, the Herbert system, is described elsewhere in this issue. In continuous systems such as this, an additional advantage is secured through preventing the possibility of chilling the castings. With the old methods, especially in the winter time, the pipes are apt to be chilled so hard as to make it almost impossible to do any machining on them or even cut them off without reheating. In the continuous systems, the iron is poured in while the mold is still hot, and a softer, tougher casting is the result.

The true explanation for the American habit of casting pipes wrong end up seems to be merely because it is easier with the equipment in use in this country, and because the makers are encouraged in the use of the easier method by the laws governing the award of municipal contracts, which practically compel the acceptance of the lowest bid without regard to the quality furnished.

A distinct step in advance has been taken by the installation of one of the English pipe-molding systems at Coshocton, Ohio. The pipe made by this system can be sold, we are informed, at a price only about one dollar per ton more than for that produced by the old method. This difference in cost is much more than offset by the superiority of the product. The success of this installation should encourage engineers to positively insist on having pipe cast in the position specified.

The development of the separately-molded system of reinforced-concrete construction goes on apace. It is now some four years since we described in these columns the first extensive application of the system to large buildings in the article on the storehouses for the Edison Portland Cement Co., at Stewartsville, N. J. These were of the most simple type; mere one-story sheds with the plainest possible details of column, beam and roof and wall slab, but the idea of casting each of the members as a separate unit was there and the application of the idea most successful.

Since then we have shown some few other instances—notably the car barns at Harrisburg, Pa., where although still restricted to one story, the architectural layout required a somewhat more involved treatment than in a plain cement mill. About two months ago we gave space to the description of a long concrete bridge at San Luis Rey, Cal., where the use of separately-molded units measurably reduced the difficulties of construction and consequently the cost. Here was a further broadening of the system in order to make it fit the extra requirements of an arch bridge.

Finally, we present in this issue two articles, on buildings in widely separate sections of this country, which, to our knowledge, are the first buildings of considerable height and standard warehouse layout to be built by this economical and, from all present appearances, very effective system.

The only reason for being of the separately-molded concrete building is economy. There can be no claim that under equal conditions of manufacture, it is stronger, more roomy or better looking than its monolithic predecessor; in these respects its highest expectation can be but equality. In the matter of cost, however, it has theoretically the better of the argument because of the reduction in the use of expensive forms, a reduction that has been the aim of all concrete users for ten years past. Forms flat on the ground on a mixing board may be of much lighter material, less complicated design and much more easily transferred for new units than when erected in the building—obviously the total cost for them must be less. So, too, the labor for erecting them and for filling them with concrete must show a considerable reduction. Unfortunately, detailed costs of the buildings shown in this issue are not given, beyond the mere statement of a reduction in cost, so we cannot judge the extent of the expected economy.

Although the opportunities for effective inspection and the increased ease of concrete deposition must result in an increased strength in the members themselves, the main criticism of the method as at first executed was in a lack of effective tie between adjoining members, thus losing that continuity which makes for both economy and strength in a monolithic structure. In the later developments this has been overcome, to a considerable extent at least, and in the buildings shown in this issue, the joints are so designed that when completed their strength should closely approximate those cast as one piece, while at the same time the extra reinforcement and concrete demanded by the discontinuous units is not of any great consequence.

To arrive at this strength it is obviously necessary that the erection should be carried out with even greater precision and care than in the building cast in place, because there is no increase in strength with age in the separately-molded building; it must be built initially as strong as required. This precision requires skilled workmen and complete preliminary studies of the layout, which in themselves tend toward safety and integrity of construction.

Some years ago we remarked that the system could not have universal application because of the restriction in sizes, of discontinuous members, of the multiplicity of required shapes in large buildings and of the unsightliness of jointed large area wall slabs. These objections do not appear so formidable to-day. The first will always be a defect of the system and narrow its application to certain layouts governed by the capacities of the handling apparatus. The second, as we have noted, is being overcome. The others are largely matters of architectural treatment. Study of the nature of the design should reduce the number of shapes to a workable minimum and a not unattractive plainness of outside wall may be the result of an effort on the architect's part to avoid unsightly wall joints and expensive ornament.

Just as there had to be a gradual evolution of a reinforced-concrete architecture from the older stone, brick and steel designs, so it may be expected that the separately-molded structures will draw away in general type from the monolithic designs they at first copied. There is bound to come a field for concrete "lumber," more-or-less standardized shapes and sizes, cast in a yard at any time and in any weather and erected in the building as separate units to be tied together with steel and concrete into a reasonably monolithic structure.

Two other articles in this issue show a special application of those same methods of economy which dictated the use of the separately-molded construction noted above. The problem of the elimination of forms and centering comes just as close to the pocketbook of the builder of masonry arches as to the pocketbook of the builder of concrete buildings, though in the former case the solution has been sought for a longer time and with less apparent success. The fixed quantities in arch construction are so many and the masses to be handled usually so great that the methods of erection and the design of the necessary centering have not permitted of much variation, except in details, through many years of practice. The novelties offered by Mr. Aylett and by Mr. Watson, as described elsewhere in this issue, are therefore especially to be noted.

The problem in the two cases was somewhat different, largely on account of the difference in size of the two arches. The Rocky River arch at the time of its construction was the largest concrete arch in the world and the design of its centering involved much more than the mere economy which is the ruling factor in the efforts to reform the falsework practice of smaller arches. What those considerations were are fully set forth in Mr. Watson's paper, together with the success with which the design fulfilled the expectations which had been had for it.

Mr. Aylett's scheme is radically different and appears at present to be applicable only to small arches. Unless some thorough system of cross-bracing or other stiffening may be provided by further design, the suspended cableway in very large arches cannot be expected to be stiff enough to permit of safe working upon it. The swaying and swinging of the ordinary small unbraced suspension bridge under a passing load is familiar enough to any one to suggest the complications of laying concrete on such a structure. The scheme, however, appears to be quite successful in the smaller size arches, and the careful studies made by Mr. Aylett for the gradually increasing sizes would indicate that he may yet find some method of applying the scheme to much larger ones.

The Aylett suspended center method is not the first of its general type. It bears a family resemblance to a method used by Mr. J. G. Strauss in the construction of the Belvidere Bridge in Illinois (Eng. News, Aug. 30, 1906, p. ►

215), though that method did employ some low falsework spanning the stream. It will be recalled that Mr. Strauss molded box-like hollow concrete voussoirs on shore and hoisted them into place by a traveler moving on a low falsework, holding each voussoir in its proper position by a line guyed back to towers over the abutments. When these voussoirs had all been placed in the arch rib, the lines were released, the rib taking its set as an arch of hollow concrete boxes afterwards to be filled in with concrete to form a solid arch rib. The construction of this bridge required a large molding plant of high first cost, so that economy could only be expected by continued use of the plant. So far as we know, such continued use, though expected, has not been realized and the Belvidere Bridge is the only one which has been built by this method.

Among the daily newspapers which joined in the fusillade against the Panama Canal work two or three years ago, The New York "Sun" was particularly notable. It continued to publish the effusions of "Cranks" and "Knockers" long after other journals had dropped the subject, and gone off after new sensations.

A well known engineer in New York City recently determined to make a test and see how far "The Sun" would go in printing rank nonsense. He, therefore, compiled a letter quite in the general style of some of the pseudo-scientific productions which "The Sun" has hitherto spread before the public in its "Anti-Panama Canal column," but with statements which remind one of Alice in Wonderland or John Phoenix.

The letter was sent to "The Sun" and was duly published in its issue of May 24. We reprint it below with the headlines under which it appeared.

Readers familiar with Panama geography will particularly appreciate the reference to "the destruction of the old French canal at Porto Bello which now forms the only completed portion of the work." The reference to "the traces of lobnitz at the hospital" ought to be immediately referred to that eminent expert on lobnitz, Bunau Varilla.

OUR GREAT CANAL.

Expression of Apprehension Concerning the Culebra Cut.

To the Editor of The Sun.—Sir: A sense of duty, mingled with a feeling of regret, is the impulse behind the words which follow:

The writer has a friendly, almost a paternal, feeling for the United States Government and for the canal. He has, at great personal and pecuniary sacrifice, sustained the high level position of two administrations against enemies who sought to ditch this great project by an attack upon the very foundations of the Gatun dam in an effort to throw up that great engineering system of locks for a lower plan of sea level. He modestly claims the ear of the public on the grounds that he professes to be an engineer, as he holds membership in all the societies, and that his familiarity with conditions on the Isthmus dates from the De Lesseps era and is founded on several personal visits. Lastly, he is a friend and warm admirer of Colonel Goethals.

The fact is that slides, too numerous to mention, have taken place at Culebra and have already shown themselves in fissures in the paleozoic rocks which form the core walls of the Gatun dam; it is even claimed that as this formation is of aqueous and not trachytic origin there can be no hope that the natural caloric effects on the ground will close the fissures, as has sometimes occurred in metamorphic strata in the earth's crust. Ancon Hill is itself affected, no less an authority than Dr. Alarosa having asserted that he has discovered of late numerous cracks, exudations and even traces of lobnitz at the hospital.

The writer has personally estimated that with a rainfall of 116 1-5 feet a year, the average of 99 years on the Isthmus, there is likely to be an erosion through slides and fissures sufficient in four and a half years time to level Ancon Hill and the Gatun dam to the height of the third flight of locks at Miraflores. These figures take no account of the Chagres floods, which have been known greatly to affect the difference in tide level between the Atlantic and Pacific oceans.

A Chagres flood, uniting with the heavier saline mixture from the Pacific and accelerated by a sudden slide from the Bohio, might create a tidal wave against which the rocks of the Gatun dam would shake like pebbles on the shore of Fire Island.

That these Culebra slides are a serious menace is well known to engineers at Bas Obispo, whose houses are in danger and who are even apprehensive lest the igneous rocks of the tertiary period on the Atlantic end of the canal be some day swept away, thus destroying all of the old French canal at Porto Bello which forms now the only completed section.

It has been noticed that the President has not paid his annual visit to the canal, no group of progressive Congressmen has gone there, and the new Secretary of War, the titular head of the work, has never been on the spot. Is this because of the fear of a slide? If so, let us not hesitate to appoint a commission, a commission of able engineers who, if they work like beavers, can and will build a dam, greater even than Ashokan or Gatun, and thereby attain the angle of rest for the alluvial algae on the slopes of the Culebra cut. W. L. S.

New York, May 23.

The natural question is, did "The Sun" take the letter seriously or did it print the letter as what Artemus Ward called "a goak" on its readers? Did its readers perceive that the letter was intended as a hoax? If not—and we are informed that several engineers even read the letter without a smile—Mr. W. L. S. has furnished an excellent proof of the utter worthlessness of newspaper news concerning technical matters, and of the extreme gullibility of the average newspaper reader.

This is not merely a matter for amusement. It is a matter which seriously affects the public welfare. Take the questions which are before the public today—highway improvement, city transit, railway regulation, industrial efficiency, city planning, sanitation and so on through a long list. Most of these public questions have to do with engineering matters, or at least with technical matters, and the lay public has to rely on the newspapers for its information—and misinformation—and on newspaper editorials to guide its opinion with reference to these questions. Is it any wonder that the public fails to appreciate competent engineers and competent engineering at their real value when its information upon these matters is obtained from such ignorant and unreliable sources?

We happen to have before us a concrete example of newspaper unreliability in the reporting of technical matters. In the fire which destroyed the Dreamland amusement resort, Coney Island, the firemen experienced considerable difficulty on account of deficient water supply from the high-pressure pumping station.

The newspaper accounts gave the impression that the high-pressure pumping plant had failed miserably to do what was expected of it, and attributed to this in large part the extent of the damage done by the flames. Our issue of June 1 gave a correct account of the pumping station's performance at this fire.

The fact was that the high-pressure pumping plant was designed for a capacity of about 4,500 vide at the utmost for 15 fire streams, since a 3-in. fire hose with 1¼-in. nozzle will deliver some 300 gals. per min. The fire-fighters seemed to think it their duty to get as many streams as possible into action and gave no heed to the fact that the pumping-station capacity was limited. By means of "Siamese" connections, with in some cases as many as six hose lines to one hydrant, they drew from the high-pressure system more than 30 streams. As a result the pressure fell too low to give a really effective stream from any of the hose lines.

This matter is of importance and interest to engineers because the Coney Island high-pressure fire pumps were among the first installations of gas-engine driven pumps for such service; and if the plant failed to do the work for which it was designed, as the newspapers declared, engineers would desire to know the fact and the reasons.

That our account of the fire was correct and that the sole cause of the low pressure was the bad judgment of the firemen in turning on more streams than the station could maintain at high pressure is shown by the following letter written by Deputy Commissioner J. W. F. Bennett of the Department of Water Supply to the Goulds Mfg. Co., builders of the Coney Island pumps:

In reply to your communication to Commissioner Henry S. Thompson under date of May 29, 1911, I have pleasure in stating that the three high-pressure service gas-engine-driven pumps at the Coney station worked satisfactorily during the Dreamland. The overdraft on the pump necessarily resulted reduction in pressure shown on the charts and tioned in the press.

A news item of the past week records the last act in a noteworthy drama which interested engineers long ago. Its beginnings go back to 1904. Formerly it might have been called a tragedy, but in a tragedy the killings come near the end, while in this case they happened at the beginning; we therefore prefer to call it a drama. A synopsis is as follows:

Act. I.—A little over seven years ago there was under construction in New York City a loft building having a framework of cast-iron columns and steel floorbeams. By March, 1904, the framework was erected for nearly the full height. On March 2 the entire pile of metalwork collapsed, killing a score or so of the workmen.* It developed that the owners were having the building erected by inexperienced contractors, without supervision, and under a series of objections and "violation" notices from the city's Bureau of Buildings. It was a "speculative builder's" job, i. e., a case of cheap but pretentious construction for the purpose of reaping a quick profit.

Act II.—The Coroner's jury investigating the collapse, and reported† that the managing owner (a Mr. Allison) and the contractors (Pole & Schwandtner) were blamable for the deaths:

We find that Eugene F. Allison and the firm of Pole & Schwandtner were *grossly criminally negligent* in the methods adopted and followed by them in the erection of said building.

The District Attorney's office also took hold of the case. A zealous young Assistant District Attorney examined witnesses, studied plans, and engaged engineering experts, with the result of reaching a similar conclusion and bringing the case before the Grand Jury. That body found an indictment against Allison, the managing owner. Shortly afterward it was reported that Allison had disappeared from the city.

Act III.—(Seven years later.) We quote the action from "The Evening World" (New York), June 7, 1911, as follows:

DEMANDS A TRIAL OR EXONERATION FOR KILLING 21.

A man came to the office of District-Attorney Whitman to-day and said he had been indicted for killing 21 persons; that he had never been arrested and, as his health was in such a precarious state that the future was uncertain, he would like to have a definite determination of the charge against him.

Eugene F. Allison, formerly a wealthy real estate and building operator, was the man who wanted to be tried for the 21 deaths, and the musty files of the District Attorney's office showed that in March, 1904, a Grand Jury had returned an indictment against him for manslaughter in the first degree, but that no warrant had been served and no action had been taken.

The indictment grew out of the collapse of what was to have been the Hotel Darlington, at Nos. 37-9 West Forty-sixth Street. While in the course of construction, in 1904, the building collapsed and 21 persons were killed outright or died from injuries.

Allison was financing the construction. John Pole and Paul Schwandtner had the contract for the steel work. The Coroner held the three men for the deaths of the victims of the collapse. The contractors were not indicted.

District-Attorney Whitman, before Judge Malone, in the Court of General Sessions, moved that the indictment against Allison be dismissed, which was promptly done.

During all the time the indictment hung over his head, Allison was actively engaged in business in this city with an office downtown.

There are many comments that might be made on the drama—which is after all a tragedy. One thinks involuntarily of that famous indictment of "the law's delay" in Shakespeare's great tragedy. One's mind turns naturally to the many, many disasters in these modern days where somebody's blunder, begotten of cupidity or carelessness, sends a dozen or a score of souls into eternity, and of the few, few cases where the proceedings of juries and attorneys and courts finally result in the punishment of the one who blundered.

But because of the law's delay it does not follow that there is no punishment. There are not a few men going about their business to-day who carry always with them, by day and by night, and will carry to their grave, the consciousness of guilt, the imagined cry of those facing death.

*Eng. News, March 10, 1904, pp. 217-219.
†Eng. News, March 24, 1904, p. 279.

the sufferings of widows and orphans. No indictment hangs over them. They are shut in by no prison walls; but their punishment is none the less sure.

Yet none would excuse on this account the law's delay—the failure to reach and punish the man whose criminal neglect causes calamity. But the punishment should be brought not on his account, not to "get even" with him. The object in punishing crime of every kind is to warn others against similar crimes. The law's delay is reprehensible because others follow in the criminal's path, thinking they too can escape scot-free, forgetting that there are punishments besides those administered by law.

We have long made it our particular business to report and describe the more notable accidents and disasters to engineering works, endeavoring in each case to bring to light the underlying causes so that suitable lessons of what to do and what not to do might be learned.

In a large proportion of "accidents," however, it is found that somebody, somewhere was neglectful of his duty. To properly punish such neglect is a necessity if we are to achieve a reasonable degree of public safety in the midst of the complicated apparatus of modern industrial life.

It is important, in the interest of public safety, that such punishment should be sure; but it is equally important that it be swift. It is the sight of swift punishment that deters the evil-doer. Lynch law with all its faults has the merit of promptness and has in fact often resulted from realization that the tardiness of the ordinary legal processes amounts to a denial of justice.

It is particularly true of the crime of negligence that if any useful end is to be gained by its punishment, the punishment must be prompt.

The public has forgotten all about the fatal accidents of last year, to say nothing of those of half a dozen years ago. If the careless ones of those days were now taken to prison, their punishment would have no significance and would teach no moral lesson to the public at large.

Efficient Business Organization and the New York State Government.

Suppose a manufacturing concern were to become impressed with the advantages of the political method of carrying on business and were to decide to adopt it in the conduct of its affairs! It would therefore be arranged that the president of the company, the vice-presidents, the general manager and the superintendents of various departments would all be elected by a popular vote of a thousand or ten thousand stockholders. Each of these officers would hold his position for one year or two years or three years. Then his term of office would end, he would leave the concern and some one else would be elected or appointed to his position. He might have displayed marvelous ability and his services might have been enormously valuable to the company. That would make no difference, for with the political method of carrying on business the theory is that one man is as good as another. Hence the man elected or appointed to a responsible Governmental office is receiving a favor—a "choice plum," as the expression goes—from his party or his constituency. He is only entitled to hold the office for a term, and must give way to some other man with a claim to recognition when his term expires.

Anyone versed in modern business methods knows that the adoption of any such system by a private concern would quickly drive it into bankruptcy. Every business man knows that the success of any business enterprise depends on efficient management. In order to secure efficient management the man who "makes good" in a responsible position must be retained. Wherever and whenever in any private firm or corporation, position of responsibility begin to be given to men, not because of their ability to fill the positions, but because of their influence with some controlling interest, at that time and in that place the concern starts on the down-hill road.

The public is just beginning to comprehend that the carrying on of the government of our cities, of our states and of the nation itself, is really carrying on a business. It is coming to understand the fact that the efficient carrying on of this business has a very direct bearing upon the comfort and welfare of all the individuals in the community; that such practical matters as the cost of living may be very greatly influenced by the efficiency with which the government business is carried on.

But the public is only beginning to faintly comprehend that in order to secure efficiency in government, the old idea that public offices are "plums" for the deserving must be absolutely done away with.

The extension of the civil service system during the past 25 years has had a great educative effect upon public sentiment, so that it is fairly well recognized to-day that among the rank and file of those who work in our city and state departments ordinary business principles must be kept in force. It is pretty well recognized that to make appointments in the street cleaning force for example, dependent on the favor of election district leaders, means on the one hand dirty streets and on the other a big burden upon the taxpayers.

It is not generally realized yet, however, that the very same considerations apply with even greater force to the higher positions in public service, and particularly those where experience and expert knowledge are essential for efficient work.

The current idea regarding the higher public offices is reflected in the newspapers. One sees current items that this man "carries off the coveted prize" from a nominating convention, that another man has just "landed a $3,000 position." The idea is still firmly rooted in the public mind that the higher official positions should be "passed around." It is commonly said that when a man has served out his term, "he ought to get out and let some one else have a chance." How absurd this idea is appears at once if we consider it applied to a manufacturing or mercantile business. If the men in high executive positions—the men who have built up any such concern—were obliged to step out at the end of a term of years, their departure would often mean, and does often mean, the end of a concern's financial success. How often does it happen that a firm with high reputation and excellent business will lose one or two of its most able men? They may be removed by death or may leave for some other connection, but many a time such a loss results in the firm's decline and even bankruptcy.

To carry on the public business with efficiency and economy necessitates just as high an order of executive ability as is required to make any private business a success. The public will never get its work done with honesty and economy until it comes to appreciate the necessity of securing able men in responsible positions and when an able man is found of retaining him.

It is fair to say that the public has few means of knowing and judging as to the work done by its high officials in positions requiring technical ability. The best it can do is to choose between the candidates for the chief offices those who show most promise of conducting the public business on business principles and to rely on them to carry out business principles—honest business principles in the conduct of their office.

A year ago Governor Dix of New York was elected on his promise to give the state a business administration.

One of the greatest forward steps in government that has been taken in the United States for a quarter century was the establishment during Governor Hughes' administration of public service commissions to control and regulate all the public utilities of the state. The example of New York has been widely copied and it is generally agreed that this is the path to be followed to reach firm ground in the relations between franchise corporations and the public.

But if the public service commission scheme is to work well, it must be administered by men of high character and competency. Governor Hughes took great pains in selecting the personnel of the commissions which he appointed. It is necessary that men to fill such positions shall be men of a very high degree of ability, in the first place, and of absolute and incorruptible honesty in the second. This means not merely personal honesty. They must not only be men who will not rob banks or pad payrolls, but they must be men with a high ideal of public service—men with judicial character— men who will decide fairly in the great matters relative to the corporations without the slightest idea of favoring one or opposing another because of political affiliations or influence.

It is a high tribute to the work done by the Public Service Commissions of New York that they have never been accused of allowing political considerations to enter into the conduct of their business. They were given an enormous task, beyond the abilities of any man or set of men to perform entirely and with absolute perfection, but their success has been such that New York's example is being followed by many other states of the Union.

The term of office of one member of each of the New York Commissions has expired and Gov. Dix has had the responsibility either of reappointing them for a second term or of selecting new candidates for the positions.

In both cases the character and the ability of the men whose term had expired, was vouched for on highest authority. They had gained experience in the work, rendering them much more competent and valuable than when first appointed. Suppose these men had held positions involving like responsibility in a well-managed private corporation, say the Pennsylvania R. R. or the Carnegie Steel Co. No one would dream of dispensing with their services because they had held the positions a certain number of years. On the contrary, in any important business the man who makes good in a high position is retained in the service at any cost.

There were, moreover, special reasons why the services of the member of the New York City Commission, Mr. Edward M. Bassett, were urgently needed. Arrangements are just being completed for the expenditure of some two hundred million dollars or more on rapid transit subway construction, to which work the present members of the Commission have given years of close duty. The stronger appeals, from the highest and most reliable sources, were made to Gov. Dix to at least delay the replacement of Mr. Bassett by another appointee until the Rapid Transit contracts could be concluded.

On the other hand there were strong influences opposed to the continuance of Mr. Bassett in office. There have, in fact, been strong influences at work against the New York Public Service Commissions from the time of their establishment. The creation of these commissions put an end to the old and profitable partnership between the public utility corporations and the political bosses. It is not necessary for a gas company or a street railway company to pay political tribute when it is protected in its rights by the public service commission. It is not necessary, that is, so long as the public service commission is kept out of politics.

Gov. Dix, therefore, if he proposed to follow business principles in conducting the business of the state, had as his first duty to reappoint the men whose terms had expired, unless he could show that they were less competent to continue in the positions than other available candidates. In the second place, if he decided to replace these men with other appointees, it was incumbent on him to find men with an equally high reputation for ability, good citizenship and freedom from entangling alliances.

And as a result of his microscopic search up and down the state for men to fulfil these requirements, the "business" Governor of New York appointed to the vacancy in the up-state commission the late chairman of the Democratic Campaign Committee; and to the vacancy in the New York City Commission he appointed a man who is known to the public chiefly by his connection with Tammany Hall.

To those who know what partnership between "Big Business" and political organizations has

meant in New York in the past, comment is unnecessary.

It need hardly be said to our readers that Engineering News has no political or partisan affiliations. We are as ready to recognize and praise excellent work by a Democratic executive as by a Republican. We have thought it proper to call attention to this matter because the interests of engineers and the engineering profession and, more than this, the public welfare, are at stake.

The state of New York, through its Public Service Commissions; through its State Engineer's Office; through its Department of Highway Construction, is carrying on a large proportion of the engineering work of the United States at the present day. It makes an enormous difference to the engineers and the taxpayers how this work is conducted.

We called attention some months ago to Gov. Dix's proposal to "reform" the highway administration of New York by making it a political organization instead of a business organization. His scheme to abolish the Advisory Board of Engineers on the barge canal work may be criticised on like grounds.

It is well that these things should be put on record so that in future if graft is uncovered in New York road work or if the high financiers are able to work their schemes secure from interference of the Public Service Commission, or if the barge canal work gets in a bad way, the public may know where to place the responsibility.

LETTERS TO THE EDITOR.

A Machine for Structural Steel Engineering!

Sir: In the issue of June 3 of the "Evening Sun," New York, in the column headed Notes for Investors, appeared this item:

Structural steel experts require only a few hours at most to estimate the amount of steel needed in the largest office buildings. They take the dimensions, height of ceilings, number of rooms, etc., and work out the cubic contents of the structure. A system of tables does the rest.

I am working on a device which, when completed, I believe, will prove to be a great boon to structural steel fabricators. By inserting in the contrivance the letter of invitation, a copy of the bid form and the contract plans, after one or two revolutions of a crank there will emerge completely detailed shop drawings with rivet and bolt lists, all duly signed with the purchaser's engineer's approval. All that is necessary to perfect this machine is a set of the above-mentioned tables, and I would greatly appreciate the information where these may be procured. Hitherto experiments involving the use of tables of logarithms and broker's daily market letters have not given satisfactory results.

Respectfully,

Inventor.

New York, June 5, 1911.

Measuring the Flow of Water in Large Pipe Lines.

Sir: Comment on the article entitled as above in your issue of May 25, may be of service to those whom modest writers on engineering subjects term "the young engineer"; generally to engineers having the problem stated before them.

This apparatus in its general idea of a current meter placed in the center of a pipe is, to the writer's knowledge, not less than 50 years old.

In some waters all the time, and in most waters at some seasons of the year, such an apparatus can not run 15 minutes without changing its rating, owing to grass and leaves and other trash floating in the water.

Such current meters are always liable to distortion, damage, and to a change of rating; and the places are few where a rating apparatus to rerate the whole mechanism is near by, or at all available.

The cost of installation and operation of Venturi meters, referred to as having been "greater than the results desired would justify," themselves depend upon how one goes about such a work. Possibly none of the pipes could have been drawn off long enough to insert a Venturi meter (which should have been put in when the pipe was built), but if they could have been drawn off, a wooden Venturi meter, at a less cost than the cost stated for an inferior current meter device, added to the value of the engineer's time spent in rating, etc., could have been built into the finished pipes and have remained in as a permanent meter, useful and accurate as long as the pipes lasted.

Several such wooden Venturi meters have been in use continuously these 20 years. C. H.

May 26, 1911.

More About the Contract System for Public Land Surveys.

Sir: Replying to Mr. Bartlett on "The Abandonment of Contract System for Public Land Surveys," in the issue of May 18, I wish to say that an engineer in charge of a railway locating party in this Western country has all the opportunities of finding out how rotten this contract system has been in the past and, there is reason to believe, might be in the future. A single year's experience will serve to show how the work has been done.

During 1910 I was in charge of a railway location survey for the Great Northern Ry. between Lewistown and Newlon, Mont., a distance of about 300 miles. Several parties were in the field and on the first 100 miles east of Lewistown it cost more to make the section ties than it did to make the location. In some cases the corners found were in error about 600 ft., and after the ties were made and placed on the map, the latter looked as though a cyclone had struck it.

In the region of the Musselshell River we crossed a square block of 16 townships where the settlers said that their corners were all set by private surveys, but none of the originals could be found and identified. So I made tracings of these township plats in the Lewistown Land Office. In doing this I was impressed with the beautiful topography found on the sheets and noticed that the surveyor had shown many of those nice Scoria Buttes, which are plentiful in that region, and apparently all the drainage. Arriving at one of the camps which was in the middle of this district and whose party had found no corners, all began to study the plats; and it was found that the elegant topography was a huge joke, not only on us, but on all mankind. In the lapse of 30 years we found a high ridge through a township where the surveyor had shown a valley with many tributaries.

Of course I do not hold him responsible for the geological changes which are possible even in so short a period as 30 years; but he should not have put so much weight on his pen.

We found three things which looked like corners in the 30 miles, and I think they have doubtless been set by private interests. In the region of Big Dry and Redwater creeks we crossed land surveys of recent date made under the contract and inspection system. The corners were all stone and had been set with great accuracy, the distance errors rarely exceeding 5 ft. But we found now and then two sets of corners not far apart, and I believe that this was in the inspected part also. It is possible that an error was found and corrected, but they had forgotten to pull up the other corner and fill the pits.

Now to be fair with Mr. Bartlett, after reading his letter, I am compelled to say that we do not want any more *cheap land surveys*. If the so-called "Civil Service" men can't give us an accurate survey, let the U. S. Geological Survey have charge of it, and if it is expensive we will appreciate it more.

I can also personally vouch for what he says of some people being charged exorbitant prices for groceries for men and provender for horses in the Northwest; but a real survey is worth the money, and that is the kind we want. The expense of a poor survey of our lands falls on the individual owners in future litigation over erroneous corners after the land has become valuable.

J. M. Phillips.

Scott City, Kan., May 26, 1911.

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"Want": See "Want" Pages.

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Entered at the New York Post-Office as Second-Class Matter.

It is generally accepted that cast-iron water pipe of the bell-and-spigot pattern is of better quality when cast with the spigot-end up. When cast in this position, a shrinkage head, which is simply an extension of the pipe at the upper end, can be easily provided. The dirt which may be present in the molten iron when poured will then rise into this shrinkage head, or extension piece, which is subsequently cut off in a lathe. Incidentally a much closer fit at the pipe joints is obtained by turning the spigot to exact size at the same time the extension piece is cut off.

When the pipe is cast with the bell-end up, on the other hand, an effective shrinkage head is scarcely practicable. The dirt in the iron rises in the mold as before but its passage up into the shrinkage head (if any be provided) is obstructed by the flare of the bell. As a result, dirt collects at this point and the pipe is weakest at the very place likely to be the most strained.

Only a prohibitive difference, therefore, between the costs of casting pipe in the two positions would justify the very general American practice of casting with the bell-end up. But that such a difference does not exist is shown by the fact that practically all water pipe is cast socket-end up in European countries and even in Japan. Many different methods of producing pipe in this position are in use, one of which, the Herbert system, is described elsewhere in this issue. In continuous systems such as this, an additional advantage is secured through preventing the possibility of chilling the castings. With the old methods, especially in the winter time, the pipes are apt to be chilled so hard as to make it almost impossible to do any machining on them or even cut them off without reheating. In the continuous systems, the iron is poured in while the mold is still hot, and a softer, tougher casting is the result.

The true explanation for the American habit of casting pipes wrong end up seems to be merely because it is easier with the equipment in use in this country, and because the makers are encouraged in the use of the easier method by the laws governing the award of municipal contracts, which practically compel the acceptance of the lowest bid without regard to the quality furnished.

A distinct step in advance has been taken by the installation of one of the English pipe-molding systems at Coshocton, Ohio. The pipe made by this system can be sold, we are informed, at a price only about one dollar per ton more than for that produced by the old method. This difference in cost is much more than offset by the superiority of the product. The success of this installation should encourage engineers to positively insist on having pipe cast in the position specified.

The development of the separately-molded system of reinforced-concrete construction goes on apace. It is now some four years since we described in these columns the first extensive application of the system to large buildings in the article on the storehouses for the Edison Portland Cement Co., at Stewartsville, N. J. These were of the most simple type; mere one-story sheds with the plainest possible details of column, beam and roof and wall slab, but the idea of casting each of the members as a separate unit was there and the application of the idea most successful.

Since then we have shown some few other instances—notably the car barns at Harrisburg, Pa., where although still restricted to one story, the architectural layout required a somewhat more involved treatment than in a plain cement mill. About two months ago we gave space to the description of a long concrete bridge at San Luis Rey, Cal., where the use of separately-molded units measurably reduced the difficulties of construction and consequently the cost. Here was a further broadening of the system in order to make it fit the extra requirements of an arch bridge.

Finally, we present in this issue two articles, on buildings in widely separate sections of this country, which, to our knowledge, are the first buildings of considerable height and standard warehouse layout to be built by this economical and, from all present appearances, very effective system.

The only reason for being of the separately-molded concrete building is economy. There can be no claim that under equal conditions of manufacture, it is stronger, more roomy or better looking than its monolithic predecessor; in these respects its highest expectation can be but equality. In the matter of cost, however, it has theoretically the better of the argument because of the reduction in the use of expensive forms, a reduction that has been the aim of all concrete users for ten years past. Forms flat on the ground on a mixing board may be of much lighter material, less complicated design and much more easily transferred for new units than when erected in the building—obviously the total cost for them must be less. So, too, the labor for erecting them and for filling them with concrete must show a considerable reduction. Unfortunately, detailed costs of the buildings shown in this issue are not given, beyond the mere statement of a reduction in cost, so we cannot judge the extent of the expected economy.

Although the opportunities for effective inspection and the increased ease of concrete deposition must result in an increased strength in the members themselves, the main criticism of the method as at first executed was in a lack of effective tie between adjoining members, thus losing that continuity which makes for both economy and strength in a monolithic structure. In the later developments this has been overcome, to a considerable extent at least, and in the buildings shown in this issue, the joints are so designed that when completed their strength should closely approximate those cast as one piece, while at the same time the extra reinforcement and concrete demanded by the discontinuous units is not of any great consequence.

To arrive at this strength it is obviously necessary that the erection should be carried out with even greater precision and care than in the building cast in place, because there is no increase in strength with age in the separately-molded building; it must be built initially as strong as required. This precision requires skilled workmen and complete preliminary studies of the layout, which in themselves tend toward safety and integrity of construction.

Some years ago we remarked that the system could not have universal application because of the restriction in sizes, of discontinuous members, of the multiplicity of required shapes in large buildings and of the unsightliness of jointed large area wall slabs. These objections do not appear so formidable to-day. The first will always be a defect of the system and narrow its application to certain layouts governed by the capacities of the handling apparatus. The second, as we have noted, is being overcome. The others are largely matters of architectural treatment. Study of the nature of the design should reduce the number of shapes to a workable minimum and a not unattractive plainness of outside wall may be the result of an effort on the architect's part to avoid unsightly wall joints and expensive ornament.

Just as there had to be a gradual evolution of a reinforced-concrete architecture from the older stone, brick and steel designs, so it may be expected that the separately-molded structures will draw away in general type from the monolithic designs they at first copied. There is bound to come a field for concrete "lumber," more-or-less standardized shapes and sizes, cast in a yard at any time and in any weather and erected in the building as separate units to be tied together with steel and concrete into a reasonably monolithic structure.

Two other articles in this issue show a special application of those same methods of economy which dictated the use of the separately-molded construction noted above. The problem of the elimination of forms and centering comes just as close to the pocketbook of the builder of masonry arches as to the pocketbook of the builder of concrete buildings, though in the former case the solution has been sought for a longer time and with less apparent success. The fixed quantities in arch construction are so many and the masses to be handled usually so great that the methods of erection and the design of the necessary centering have not permitted of much variation, except in details, through many years of practice. The novelties offered by Mr. Aylett and by Mr. Watson, as described elsewhere in this issue, are therefore especially to be noted.

The problem in the two cases was somewhat different, largely on account of the difference in size of the two arches. The Rocky River arch at the time of its construction was the largest concrete arch in the world and the design of its centering involved much more than the mere economy which is the ruling factor in the efforts to reform the falsework practice of smaller arches. What those considerations were are fully set forth in Mr. Watson's paper, together with the success with which the design fulfilled the expectations which had been had for it.

Mr. Aylett's scheme is radically different and appears at present to be applicable only to small arches. Unless some thorough system of cross-bracing or other stiffening may be provided by further design, the suspended cableway in very large arches cannot be expected to be stiff enough to permit of safe working upon it. The swaying and swinging of the ordinary small unbraced suspension bridge under a passing load is familiar enough to any one to suggest the complications of laying concrete on such a structure. The scheme, however, appears to be quite successful in the smaller size arches, and the careful studies made by Mr. Aylett for the gradually increasing sizes would indicate that he may yet find some method of applying the scheme to much larger ones.

The Aylett suspended center method is not the first of its general type. It bears a family resemblance to a method used by Mr. J. G. Strauss in the construction of the Belvidere Bridge in Illinois (Eng. News, Aug. 30, 1906, p.

meant in New York in the past, comment is unnecessary.

It need hardly be said to our readers that Engineering News has no political or partisan affiliations. We are as ready to recognize and praise excellent work by a Democratic executive as by a Republican. We have thought it proper to call attention to this matter because the interests of engineers and the engineering profession and, more than this, the public welfare, are at stake.

The state of New York, through its Public Service Commissions; through its State Engineer's Office; through its Department of Highway Construction, is carrying on a large proportion of the engineering work of the United States at the present day. It makes an enormous difference to the engineers and the taxpayers how this work is conducted.

We called attention some months ago to Gov. Dix's proposal to "reform" the highway administration of New York by making it a political organization instead of a business organization. His scheme to abolish the Advisory Board of Engineers on the barge canal work may be criticised on like grounds.

It is well that these things should be put on record so that in future if graft is uncovered in New York road work or if the high financiers are able to work their schemes secure from interference of the Public Service Commission, or if the barge canal work gets in a bad way, the public may know where to place the responsibility.

LETTERS TO THE EDITOR.

A Machine for Structural Steel Engineering!

Sir: In the issue of June 3 of the "Evening Sun," New York, in the column headed Notes for Investors, appeared this item:

Structural steel experts require only a few hours at most to estimate the amount of steel needed in the largest office buildings. They take the dimensions, height of ceilings, number of rooms, etc., and work out the cubic contents of the structure. A system of tables does the rest.

I am working on a device which, when completed, I believe, will prove to be a great boon to structural steel fabricators. By inserting in the contrivance the letter of invitation, a copy of the bid form and the contract plans, after one or two revolutions of a crank there will emerge completely detailed shop drawings with rivet and bolt lists, all duly signed with the purchaser's engineer's approval. All that is necessary to perfect this machine is a set of the above-mentioned tables, and I would greatly appreciate the information where these may be procured. Hitherto experiments involving the use of tables of logarithms and broker's daily market letters have not given satisfactory results.

Respectfully,

Inventor.

New York, June 5, 1911.

Measuring the Flow of Water in Large Pipe Lines.

Sir: Comment on the article entitled as above in your issue of May 25, may be of service to those whom modest writers on engineering subjects term "the young engineer"; generally to engineers having the problem stated before them.

This apparatus in its general idea of a current meter placed in the center of a pipe is, to the writer's knowledge, not less than 50 years old.

In some waters all the time, and in most waters at some seasons of the year, such an apparatus can not run 15 minutes without changing its rating, owing to grass and leaves and other trash floating in the water.

Such current meters are always liable to distortion, damage, and to a change of rating; and the places are few where a rating apparatus to rerate the whole mechanism is near by, or at all available.

The cost of installation and operation of Venturi meters, referred to as having been "greater than the results desired would justify," themselves depend upon how one goes about such a work. Possibly none of the pipes could have been drawn off long enough to insert a Venturi meter (which should have been put in when the pipe was built), but if they could have been drawn off, a wooden Venturi meter, at a less cost than the cost stated for an inferior current meter device, added to the value of the engineer's time spent in rating, etc., could have been built into the finished pipes and have remained in as a permanent meter, useful and accurate as long as the pipes lasted.

Several such wooden Venturi meters have been in use continuously these 20 years. C. H.

May 26, 1911.

More About the Contract System for Public Land Surveys.

Sir: Replying to Mr. Bartlett on "The Abandonment of Contract System for Public Land Surveys," in the issue of May 18, I wish to say that an engineer in charge of a railway locating party in this Western country has all the opportunities of finding out how rotten this contract system has been in the past and, there is reason to believe, might be in the future. A single year's experience will serve to show how the work has been done.

During 1910 I was in charge of a railway location survey for the Great Northern Ry. between Lewistown and Newlon, Mont., a distance of about 300 miles. Several parties were in the field and on the first 100 miles east of Lewistown it cost more to make the section ties than it did to make the location. In some cases the corners found were in error about 600 ft., and after the ties were made and placed on the map, the latter looked as though a cyclone had struck it.

In the region of the Musselshell River we crossed a square block of 16 townships where the settlers said that their corners were all set by private surveys, but none of the originals could be found and identified. So I made tracings of these township plats in the Lewistown Land Office. In doing this I was impressed with the beautiful topography found on the sheets and noticed that the surveyor had shown many of those nice Scoria Buttes, which are plentiful in that region, and apparently all the drainage. Arriving at one of the camps which was in the middle of this district and whose party had found no corners, all began to study the plats; and it was found that the elegant topography was a huge joke, not only on us, but on all mankind. In the lapse of 30 years we found a high ridge through a township where the surveyor had shown a valley with many tributaries.

Of course I do not hold him responsible for the geological changes which are possible even in so short a period as 30 years; but he should not have put so much weight on his pen.

We found three things which looked like corners in the 30 miles, and I think they have doubtless been set by private interests. In the region of Big Dry and Redwater creeks we crossed land surveys of recent date made under the contract and inspection system. The corners were all stone and had been set with great accuracy, the distance errors rarely exceeding 5 ft. But we found now and then two sets of corners not far apart, and I believe that this was in the inspected part also. It is possible that an error was found and corrected, but they had forgotten to pull up the other corner and fill the pits.

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using a minimum of oil. A portion of the station force alternates between operation and repairs. The civil service governs the whole force.

Several members complimented Mr. McMillan both the paper and the results obtained under his direction.

Restoration of Old Distributing Systems.

Under this heading, Mr. Burt B. Hodgman, Jun. Am. Soc. C. E., presented data on pipe cleaning by contract. Some of this was in tabular form and is reproduced herewith.

Charges for Public Hydrant Service.

Under the comprehensive title, "Some Fundamental Considerations in the Determination of a Reasonable Return for Public Hydrant Service," Messrs. Leonard Metcalf, Emil Kuichling and W. C. Hawley, M's. Am. Soc. C. E., presented the paper mentioned in our introduction to this report. Mr. Metcalf read extracts from the paper, which was far too lengthy and was not designed for presentation in full. Elsewhere in this issue we print extensive selections from the paper, together with some of the many tables and all of the diagrams which were included in it.

Mr. Metcalf's presentation of this paper, together with a lantern-slide talk on the Panama Canal by Mr. Dabney H. Maury, M. Am. Soc. C. E., occupied the whole of a long evening session, and held the attention of the audience throughout. A discussion on the hydrant charge paper was, therefore, deferred until the next morning, when Mr. Metcalf stated that the object of the paper was to present a method for the fair distribution of the cost of water service between public and private consumers. He urged that it was desirable to get into the habit of thinking of the cost of fire protection in per capita units instead of on a per hydrant basis.

Mr. F. C. Kimball, M. Am. Soc. C. E., of Boston, remarked that the paper covered a field not heretofore covered elsewhere to his knowledge and should lead both to the building of waterworks where none exist and to the reinforcement of existing works—meaning, of course, on the fire-protection side. Insurance premiums, Mr. Kimball said, never cover all the tangible loss in case of fire and can never prevent various intangible losses. A total annual charge of $15 a year for in-between fire hydrants would warrant a material reduction of insurance rates and would effect the reduction of fire losses as well. Mr. Morris Knowles, M. Am. Soc. C. E., of Pittsburg, said that the equitable distribution of cost of waterworks service between public and private consumers is just as important in municipal as in private works. Not long ago the Wisconsin Public Service Commission prohibited the city of Madison from supplying free water to any one, including even city departments. Mr. Maury said there are two beneficiaries to improved fire service: property owners and fire insurance companies. The water companies and departments have to publish their financial accounts, but the fire companies do not.

Further remarks by Mr. Maury and other speakers gave evidence of strong belief that fire insurance companies should be under as rigid public supervision as are banking companies, on the one hand, and, on the other, the various public utility companies. It was also said, either directly or in spirit, by a number of speakers that the fire insurance companies ought to be compelled to say in advance of water-works improvements which they were urging just what reduction and rates they would make if the improvements were carried out, and that they should also be compelled to fulfill their promises.

Mr. J. N. Chester, M. Am. Soc. C. E., of Pittsburg, took up cudgels very strongly against the fire insurance companies. Some of his allegations were: failure to keep promises; unjustness of penalties imposed with failure to remove them after the cause for the penalties had (in Mr. Chester's opinion) been remedied; and also to the effect that the water-works men are subject to fire insurance rulings made by boys just out of school, and that, in his belief, the underwriters are a combination in restraint of trade. These remarks led a Newark member to make a motion to the effect that the insurance interests be given an opportunity to prove or disprove Mr. Chester's assertions, before they went out as the sense of the Association. A controversial discussion arose, in the course of which it was pointed out that the Annual Proceedings of the Association always contain a disclaimer of responsibility for opinions of individual members and that such action as was proposed would restrain members from free discussion. Finally, Mr. Chester said that he would revise his remarks before publication, and the Association voted to lay the resolution on the table.

Reverting now to the other phases of the discussion, Mr. Chester expressed himself as disagreeing with Mr. Kimball's suggestion for an extra charge for in-between hydrants, at least if this were to be borne by the city as a whole. Such hydrants, Mr. Chester maintained, were generally placed in a congested district and should be charged against property there. Mr. Dow R. Gwinn, Terre Haute, Ind., remarked that the paper by Mr. Metcalf and his associates deserved to go between the covers of a textbook. Various other speakers gave equally high commendation to the paper.

There was, as might be expected, a general endorsement of the position taken by the authors of the paper to the effect that water used for fire protection and other public purposes should be paid for at its full value, even in the case of municipally-owned works.

The Dangers of Emergency Intakes.

Prof. W. P. Mason, of Troy, N. Y., made some brief statements regarding a number of outbreaks of typhoid fever which had occurred at various places due to keeping available for possible emergency uses intakes to supplies which had been abandoned because they were believed to be dangerously polluted. He put the whole matter in a nutshell by saying that it was an alternative between having one's house burn down and dying of typhoid fever. From this point of view, of course, there was no conclusion but what as a general proposition these emergency intakes should be destroyed or made non-usable.

Wood Stave Pipe.

Mr. Chalkley T. Hatton, M. Am. Soc. C. E., Wilmington, Del., in opening a brief paper on this subject, remarked that he thought it advisable to answer through the Association some of the questions which he was more or less constantly receiving on the subject. He gave some historical information and described the continuous or made-in-place and also machine-made types of pipe. The latter ranged from 3 to 36 ins. in diameter and, like the continuous pipes, are now made from staves, but with continuous banding for each length pipe, the bands or wire being applied by machinery under tension.

Wood pipes are used under pressures up to 200 lbs.; above this there is likely to be leakage. A test showed that at 250 lbs. water oozed through the joints and at 300 lbs. it squirted through the joints in small jets. On reducing the pressure from 300 lbs. to zero and then increasing the pressure to 200 lbs., there were no leaks, showing that the elastic limit of the bands had not been exceeded. Banded continuous stave pipe has been in use 50 years with good results. Where wood pipe is laid in salt marshes or in fills of acid material, copper-clad steel wire should be used. Among the advantages which wood pipe has over cast-iron are: lower freight and cartage charges; less depth of trench; no bell holes; no lead or hemp, and no fuel for melting lead.

In conclusion, Mr. Hatton suggested that the comparative costs and advantages of wood pipe, as contrasted with cast-iron or steel, are well worth looking into where a new pipe is to be laid.

Water Rates.

Mr. George G. Earl, M. Am. Soc. C. E., Engineer and Superintendent of the Sewerage and Water Board, New Orleans, presented a scientific analysis of the proper basis of charging for water supplied both to private consumers and the city. The study was made concrete by the fact that it was based on the conditions at New Orleans, and not only this but was the actual basis of determining water rates there after it had been decided to adopt the universal meter system on completion of the new municipal system with some 515 miles of water mains.

In opening his paper Mr. Earl stated that the increasing extent to which public-service commissions are regulating rates of all sorts makes it desirable to put water rates on a scientific basis, to prevent exorbitant rates and unjust discrimination. Heretofore there has been a blind copying of water rates regardless of local conditions. Gas companies would never think of adopting flat rates, but the cost of gas and of water per 1,000 cu. ft. is about the same.

As we hope to publish an abstract of Mr. Earl's paper at a later date, we will say little further regarding it here, except to state that the principles and practice as adopted at New Orleans, which Mr. Earl set forth were (1) to divide the cost of service into its component parts, particularly as regards service to public and to private consumers, and then (2) to determine a charge for fire-protection service, based upon both capital charges and operating expenses. This done (3) the rates for private consumers were founded

RESULTS OBTAINED BY THE CLEANING OF OLD WATER MAINS IN VARIOUS LOCALITIES IN THE UNITED STATES.

	Location.	Diam., ins.	Coated?	Length tested, ft.	Discharge, gals. per min. Before cleaning	Discharge, gals. per min. After cleaning	Frictional loss per 1,000 ft. Before cleaning.	Frictional loss per 1,000 ft. After cleaning.	Per cent. increase. In discharge.	Per cent. increase. Carrying capacity.	Nature of stoppage.
1	Philadelphia, Pa....	6	No	447	364	710	120.0	46.0	95	215	Mud and corrosion
2	Brooklyn, N. Y.....	6	No	806	176	623	73.0	81.0	254	231	Corrosion
3	Brooklyn, N. Y.....	8	No	680	349	877	81.0	45.0	151	284	Corrosion.
4	Brooklyn, N. Y.....12		No	950	1,235	3,754	98.0	69.0	204	265	Corrosion
5	Brooklyn, N. Y.....30		Yes	1,863	6,050	7,350	5.1	0.0	...	105	Pipe sponge & corrosion
6	West Virginia	3.87	Yes	822	...	390	...	137.5	...	...	Corrosion
7	West Virginia	5.93	Yes	1,050	...	725	...	56.8	...	...	Corrosion
8	West Virginia.....	8	Yes	1,008	...	1,215	...	31.9	...	...	Corrosion
9	Perth Amboy, N. J..	4	Yes	500	247	477	166.0	143.0	91	105	Corrosion
10	Perth Amboy, N. J..	6	Yes	901	561	739	65.4	48.4	32	51	Corrosion
11	Pittsburg, Pa.....	8	Yes	3,294	730	1,620	...	...	121	...	Corrosion
12	Belle Plaine, Iowa..	6	Yes	5,044	248	335	39.8	9.7	35	174	Lime deposit
13	W'st'rn Pennsylvania	6	Yes	822	...	830	...	82.0	...	...	Corrosion
14	W'st'rn Pennsylvania	4	Yes	1,100	...	338	...	90.0	...	...	Corrosion
15	Troy, N. Y.....	6	Yes	410	443	703	94.7	46.0	59	130	Corrosion
16	Camden, N. J.....	4	No	420	100	227	...	...	127	...	Corrosion
17	Camden, N. J.....	8	No	...	135	740	...	...	375	...	Corrosion
18	Cumberland, Md....	6	Yes	2,200	403	802	...	...	100	...	Slime, mud & corrosion
19	Madison, Ind.....	4	No	924	90	262	102.0	90.0	191	211	Mud and corrosion
20	Wheeling, W. Va...	6	....	...	320	890	...	...	178	...	Iron corrosion
21	Lockport, N. Y.....	6	Yes	1,100	315	742	...	...	135	...	Slime and corrosion
22	Little Rock, Ark...	6	Yes	1,090	374	1,021	154 6	96.8	170	344	Corrosion
23	Pittsburg, Pa.....	6	Yes	1,800	252	671	...	...	166	...	Corrosion
24	Pittsburg, Pa.....	4	Yes	1,834	178	384	...	...	116	...	Corrosion
25	Pittsburg, Pa.....	4	Yes	905	160	485	...	...	203	...	Corrosion
26	New York City, N.Y.	6	....	650	435	765	...	...	76	...	Corrosion
27	Rochester, N. Y.....10		Yes	1,045	1,125	1,740	48.0	30.0	55	110	Iron Corrosion
	This test both before and after cleaning included two 45° bends and 45 ft. of dirty pipe.										
28	Atlanta, Ga.....30		Yes	...	...	...	...	...	...	...	.....
	Pump could only drive 11,880,000 gals. per 24 hrs. into reservoir before cleaning, and pumping against 110 lbs. After cleaning the line the same pump discharged 17,820,000 gals. per 24 hrs., against the same head.										
29	Carbondale, Ill.....	8	Yes	11,574	415	407	...	...	...	...	Clay mud scale
	In this pipe water was pumped through 5,000 ft. of new 12-in. pipe also and total head pumped against when discharging into an open tank 45 ft. higher than the pump discharge was 140 lbs. before cleaning, while after cleaning the total head including the frictional loss was 48 lbs.										
30	Centralia, Ill.....12		Yes	11,000	...	...	...	...	...	...	Mud
	In this force main the average rate of consumption was 2,000,000 gals. per day, average pressure at pumping station was 90 lbs. both before and after cleaning. Average pressure at City Hall before cleaning was 30 lbs. and after cleaning 60 lbs.										

on a determination of what might be termed a "readiness to serve" charges and the further determination of a flat meter rate. For the sake of convenience and simplicity, and to avoid the necessity of too much explanation, argument and possible friction, the "readiness to serve" charge was virtually made a minimum meter charge, offsetting against a given quantity of water per unit of time (selected in accordance with the character of consumption) and varying with the size of the meters. There is also a further variation, for ⅝-in. meters only, according to the number of persons and rooms in and occupied by a family.

This scheme is novel among other things in its adaptation of the sliding-scale principle to what might be termed a minimum charge rather than to the quantity of water consumed. In its actual workings, the extremes are a ⅝-in. meter and connection serving not over two persons and rooms and entitling the consumer to 10,000 gals. of water per year with a minimum cost of $5, whereas an 8-in. meter, with a yearly consumption of 970,000 gals., calls for a minimum yearly charge of $194. All water in excess of the quantities corresponding with the minimum rates is charged at 10 cts. per 1,000 gals. The sum and substance of the whole matter, in Mr. Earl's opinion, is that, having eliminated the cost of doing business with each consumer, the charge of water shou'd depend solely upon the amount of water used. It may be added that all water services in New Orleans are now metered.

In the discussion of Mr. Earl's paper which ensued, there was much approval of the plan advanced for determining water charges. Where dissent was expressed it was generally either from those who had not grasped the essential point of the paper or who thought the principles laid down were not applicable to private water companies. Some spoke in defense of the sliding scale for meter rates, but appeared to fail to see that the sliding-scale principle was to some extent recognized in the minimum charge. Others objected to a straight or flat meter rate on the ground that large consumers, having the alternative of establishing private supplies, would be lost if they were not given special consideration.

Mr. Theodore A. Leisen, M. Am. Soc. C. E., Louisville, Ky., said that he had recently submitted a report on the meter question to his water board, in which he had arrived at much the same general conclusion as that reached by Mr. Earl, but did so by a short cut. Only a relatively small percentage of the taps are metered in Louisville, and the law permits no charge for water supplied for public purposes. In the report named, which will be printed in the Proceedings of the Association, Mr. Leisen recommended a minimum or service charge of from $6 up and a flat meter rate of 5 cts. per 1,000 gals. The minimum charge would be absolute; this would not cover the stated quantity of water above which the flat rate would apply.

Mr. E. W. Bemis, of New York City, advanced the argument that more than one rate for public service was against public policy, especially if charged by municipal plants. Gas rates the world over, with but few exceptions and regardless of whether the works are publicly or privately owned, are the same for all consumers.

Mr. Chester remarked that Mr. Earl's paper followed others which would be of great value to rate-making public-service commissions free of political or commercial influences, but for many small private water companies he thought the principles laid down would spell ruin. Mr. Chester also thought that large private consumers should be charged what it would cost them to pump the water from works of their own. He might, however, concede all that Mr. Earl had suggested except the flat meter rate.

Hot Water Troubles.

The paper on this topic by Mr. George C. Whipple, M. Am. Soc. C. E., New York City, has already been mentioned as one of high value. It went broadly and deeply into the subject, and will be given consideration in these columns at some length in a later issue.

Mr. J. M. Diven, of Charleston, S. C., described some experiments which he had made in the hope of throwing light on the "red water plague"—another name for the hot water troubles discussed by Mr. Whipple. Some three years ago Mr. Diven put in a small heating plant with a galvanized-iron boiler to which he attached about 150 ft. of black ungalvanized-steel pipe and the same length of galvanized-steel pipe. The ungalvanized pipe was soon thrown out of the test as having proved itself unfit for use on account of the red water which came from it. After some two and a half years' experience with the galvanized-steel pipe, it was concluded that it gave rise to a material increase in color and iron contents. A test of what purported to be wrought-iron pipe gave results not materially different from the steel pipe. A short time ago a copper boiler and a brass coil were substituted for the galvanized-iron boiler and a greater length of pipe was put in for testing purposes. Thus far this combination gives a reduction in color rather than an increase. Mr. Diven stated that the general results of his experiment seemed to support his theory that hot water trouble is due to the character of the material used in house plumbing and piping.

Mr. Rudolph Hering cited some experiments made thirty years ago in Scotland, from which it was concluded that corrosion of iron and steel pipes was due to electrical action and that wrought-iron pipe corroded less than steel because it contained less carbon. Acting in accordance with these general ideas, Mr. Herman Schussler, Chief Engineer of the Spring Valley Water Co., adopted wrought-iron in place of cast-iron for water mains many years ago, insisting on an almost complete exclusion of carbon from the pipe. The results had seemed to justify this course.

Mr. F. N. Speller, Metallurgical Engineer, of the National Tube Co., Pittsburg, Pa., stated that experiments made by his company had led to the abandonment of the manufacture of wrought-iron pipe. In the early days considerable wrought-iron pipe had been made on the ground that it had greater homogeneity than steel pipe. To-day different metal is chosen for steel pipe than for other steel products. As to the character of pipe used, Mr. Speller remarked that it is largely in the control of engineers. Pipe should be made to specifications. Manufacturers, Mr. Speller added, will gladly cooperate with the engineers and will welcome standard specifications.

Mr. Robert S. Weston, Assoc. M. Am. Soc. C. E., Boston, Mass., said he could confirm all Mr. Whipple's general statements from his own experience. He also remarked that those who have been over the magnificent plant of the National Tube Works feel that every effort is being made to get greater homogeneity of material. It is expected that still further improvement will be made in the future.

The Interpretation of Water Analyses.

Mr. D. D Jackson, of New York City, outlined the general methods and value of physical, chemical, microscopical and bacterial analyses, proceeding for the most part along the lines well known to those who have followed the subject closely but which need to be brought home to the average water-works superintendent. Bacterial analyses were said by Mr. Jackson to be of importance. B. coli, he stated, should not often be found in 1 c. c. of surface water and never in ground water. In the future much more stress will be placed on certain spore-bearing bacterial than is now done. A number of these have been isolated by the author and were stated by him to be virulent in character, and especially dangerous to children. A well-chosen selection of lantern slides was presented, showing the chief type of harmful organisms found in water.

A slide which was doubtless new to most of those present brought out strikingly the difference between the appearance of B. coli and typhoid bacteria. Mr. Jackson also stated that by methods now available typhoid bacillus had probably been isolated by twelve of fifteen analysts during the past year. A number of spore-bearing, water-borne bacteria were shown, which, the author said, are known to cause testinal diseases of children.

Water Purification.

Dr. J. L. Leal, of Paterson, N. J., presented a lengthy paper, in which he reviewed the [illegible] played by water in the human economy and scribed the various systems of water purification now in vogue. He thought the time [illegible] come to give up slow sand filtration entirely in favor of mechanical filtration, and at the same time advocated an extension of the use of hypochlorite as a water disinfectant. Speaking of hypochlorite, he laid stress on the fact that the potential oxygen and not the available chlorine was the real measure of efficiency. The latter term, however, has come into general use so that for purposes of convenience it is necessary to retain it. In his own work he had never used, except for experimental purposes, more than 15 parts of available chlorine per 1,000,000 gals. of water. The maximum figure named was used at Omaha, Neb. As to tastes and odors, he was of the opinion that where tastes are reported it is really odor that is detected. At any event, there is, in his opinion, no occasion for any odor if hypochlorite is properly used. It is absolutely essential to have a laboratory in connection with the use of hypochlorite and to use it frequently. Both laboratories and intelligent supervision generally have been lacking in connection with the use of hypochlorite at many places in the United States. Dr. Leal showed a photograph of a portable hypochlorite plant being put out apparently by the New Jersey General Security Co., of Paterson, N. J.

Prof. Edward Bartow, of Champaign, Ill., remarked that Dr. Leal had done well to emphasize the necessity of laboratory control. Prof. Bartow also called attention to the fact that the Minnesota State Board of Heath has portable hypochlorite plants available for emergency use when necessary throughout the state, and Prof. Frederick P. Bass, of Minneapolis, gave a brief description of these plants (see Eng. News April 6, 1911).

Other Papers.

There were a considerable number of additional papers on the program, some of which were read by title only, owing to the absence of the authors, while others required little or no mention. We abstract elsewhere in this issue a noteworthy paper by Mr. Allen Hazen, M. Am. Soc. C. E., New York City, in which he reviewed some of the relative merits of steel and cast-iron pipe and came out quite strongly in favor of steel pipe under stated conditions. A paper entitled "Water Softening by Means of Zeolith" by Mr. Boris N. Simin, of Moscow, Russia, was reported as being on the way to this country. This with other papers read by title will, it is expected, appear in the annual volume of the Proceedings. Another paper scheduled to come from abroad was one entitled "Sidney (Australia) Water Supply, Its History and Management," by Charles Walter Smith. Other papers which we will give by title and author only, some of which were not read, are as follows: "High-Pressure Fire Service Compared with Portable Fire Engines," Charles A. Hague, M. Am. Soc. C. E.; "Compressed Air in Water-Works Construction," Alexander Milne; "The Investigation of Underground Water Waste in Washington, D. C.," W. A. McFarland, M. Am. Soc. C. E.; "Stripping Reservoir Sites," H. G. Coventry, and "Ultra-Violet Ray Sterilization," A. E. Walden.

Mr. C. C. Brown, M. Am. Soc. C. E., of Indianapolis, read a paper on "Methods of Keeping Records of Improvements to Established Water-Works Plants." This paper consisted largely of presentation and description of forms for disbursements, stock keeping and construction costs. Particular attention was given to depreciation.

Question Box.

As has already been stated, a long list of questions was prepared in advance and sent out to the members for the purpose of eliciting practical bits of experience. Discussion on only a few of these questions will be noted here. As to the advisability of using portable power plants to keep trenches dry, the general opinion

was affirmative. Mr. Albert Wehr, of Baltimore, Md., said that his company (supplying suburbs of Baltimore) has a gas engine and air compressor which it moves about for use both to drive a calking hammer and to pump water from wet trenches.

The advisability of using unfiltered water for washing mechanical filters appeared, in the opinion of those who discussed the subject, to be largely a question of local conditions and expediency. Sometimes no other course is possible without considerable inconvenience or expense. The saving, it appears, is largely offset, if plants are properly operated, by the increase in wash water due to "after wash," or wasting the first flow of filtered water after washing.

LEADITE.—A prolific source of discussion for a few years past has been the advantages and disadvantages of leadite as a substitute for the ordinary old-time calked lead joint. Leadite, the various speakers seemed to agree, is a compound consisting largely of sulphur and iron. Of the written and oral answers to the leadite question this year, a considerable number reported unsatisfactory, and while a considerable but apparently less number reported satisfactory experiences. In several instances it appeared that those reporting unsatisfactory results with leadite had merely tested it in a comparatively few joints, largely in an experimental way. It also appeared that where the material had been more extensively used, in some cases it had not been properly manipulated. Furthermore, it appeared that some of the reported unfavorable results were very likely due to prejudice or even direct opposition on the part of labor gangs who were averse to having calkers displaced. In one or two instances the data presented seemed to indicate that notwithstanding a fair trial leadite had not been as satisfactory as lead joints.

Mr. W. C. Hawley submitted a fairly long written account of his own satisfactory experience with leadite on 16 miles of pipe, extending over a number of years. He has abandoned lead joints except for special conditions. Mr. Hawley's experience as regards the care necessary in melting and pouring of leadite seemed to throw considerable light upon the unfavorable results reported by a number of the writers or speakers. Particular care must be used in bringing the leadite to the right temperature, and it is also necessary to maintain a head of 4 to 6 ins. on the leadite when it is poured in order to completely fill the upper part of the joint.

Mr. Yeager, of Lewistown, Pa., reported experience with leadite during the last seven years, but mostly in 1906-7. Altogether, he now has 45 miles of mains with lead and 20 miles with leadite joints. The comparative leakage from the two kinds of joints in the last four years, with pressure of from 75 to 115 lbs., has been as follows:

	Lead.	Leadite.
1907	18	22
1908	19	43
1909	17	18
1910	14	15
Totals	68	98

Unfortunately, the number of miles of pipe having the two classes of joints was not stated for each of the years, but even so it is apparent which has shown the greatest number of leaks per mile.

Mr. Metcalf said he had used leadite at Concord, Mass., with saving and success. He corroborated Mr. Hawley's statement that a head of 4 to 6 ins. is needed in order to fill the upper part of the joint. Mr. Gwinn reported having laid 500 ft. of pipe of leadite two or three years ago with no leaks and five miles last year, also with satisfactory results. Mr. Weston suggested that in melting the leadite the same general precautions should be used as are necessary when making sand and sulphur sewer pipe joints.

Mr. R. N. Ellis, of Jacksonville, Fla., reported variable results with leadite. He used this joint material early. First, he laid a half mile and waited a year to see what satisfaction it gave. Finding it satisfactory, he continued its use. Later on, leaks occurred in a high-pressure line with leadite joints where the joint room was very small, so that he had to substitute lead. He also had some leaks on a low-pressure line laid about the same time. As a result of his later and more unsatisfactory experience, he has stopped using leadite for the present.

BUSINESS AND ENTERTAINMENT.

MEMBERSHIP.—At the opening session the secretary reported a total membership of 876, of whom 7 were honorary, 772 were active and 97 were associate (supply men, water boards, etc.). The 86 new members added at the first session brought the membership up to 962, and additions at later sessions raised the number to about 970.

COMMITTEE REPORTS.—Mr. H. E. Keeler, of Chicago, Chairman of the Finance Committee, announced the welcome news that every obligation of the Association to the end of the fiscal year just closed had been met and that there was a net cash balance of $92, besides $21.60 paid in on account of the 1911-12 dues. By retrenchment during the year and by responses to the extent of $1,500 to a special assessment, not only the obligations of the year but also several years of back salaries due the secretary had been paid. The ordinary general receipts during the year were about $5,580.

Mr. Keeler also reported that a budget for 1911-12 had been framed, which assumed total receipts of $6,300 and disbursements of about $6,100. This is a new departure for the Association.

The Committee on Electrolysis, through Mr. Dabney H. Maury, M. Am. Soc. C. E., Peoria, Ill., reported that the decision of the lower U. S. Court in the Peoria case disagreed with some of the findings of the master or referee, but that the court has not yet filed its decree. The Committee sees no reason for changing its conclusions of several years ago.

The Committee on Uniform Annual Accounts and Reports, through its Chairman, Mr. Albert H. Wehr, of Baltimore, Md., submitted a somewhat less voluminous accounting scheme than the one printed in the last annual report, but advised no final action before next year. Representatives of this and other associations had accepted an invitation from the U. S. Bureau of the Census to join in a conference on waterworks accounting held at Washington during the year. The Wisconsin Public Service Commission has expressed a willingness to adopt the Association scheme of accounting as soon as the Committee and the Census agree upon its final form, and the new Public Utilities Commission of Maryland has already adopted the present tentative scheme.

The committees on a National Bureau of Health and on Depreciation reported progress. The Committee on Reorganization, which has been in existence for several years, was discharged, in view of the fact that the Association is not in condition to enter upon any materially enlarged program at the present time.

NEW OFFICERS AND NEXT MEETING PLACE.—In accordance with a time-honored custom which is seldom broken by this Association, the election of officers at Rochester was chiefly a matter af advancing vice-presidents up the list and choosing the new man for the lowest vice-presidency; while most of the remaining officers were simply reelected. An opposition candidate for the presidency was put up in the person of Mr. Dow R. Gwinn, Second Vice-President during 1911-12, but he received only 33 votes against 154 for Mr. Alex. Milne, Superintendent of Water-Works, St. Catherines, Ont., who was First Vice-President during the past year. Mr. Gwinn, however, was made First Vice-President for 1911-12, without opposition, and in like manner Messrs. Robert J. Thomas, Superintendent of Water Works, Lowell, Mass., John A. Affleck, President Water Board, Harrisburg, Pa., and George C. Earl, General Superintendent Sewerage and Water Board, New Orleans, La., were also advanced one step further up the vice-presidential, or, perhaps we should say, the presidential ladder. Mr. Theodore Leisen, Chief Engineer, Water Department, Louisville, Ky., and Mr. Charles R. Henderson, Davenport, Ia., were nominated for the fifth vice-presidency, but, Mr. Henderson withdrawing, Mr. Leisen was unanimously elected. Mr. John M. Diven, Charleston, S. C., was reelected as Secretary-Treasurer, which office he has now held for many years past. As a just tribute to the excellent work done by the Finance Committee, consisting of Messrs. H. E. Keeler, Chicago; Leonard Metcalf, Boston, and Charles R. Henderson, Davenport, Ia., these three were reelected without opposition and with loud acclamation and approbation.

The most fully attended session at any of the conventions of this Association is the one in which the selection of the next meeting place occurs. Here the associate members have their only opportunity of voting, and here much oratory is displayed. The contestants this year were Richmond, Va., which came within six votes of capturing the convention in opposition to Rochester a year ago; Minneapolis, Minn., and Louisville, Ky. Although it takes a majority of all the votes cast to determine the next meeting place, Louisville won by a large majority on the first ballot, the actual figures being: Louisville 167, Richmond 62 and Minneapolis 26, or a total of 255.

It should not be assumed that the associate members were in evidence only at the session for the election of officers. A goodly number of them was present at many if not all of the sessions, and they were peculiarly fortunate in being able to display their numerous and extensive exhibits of water-works appliances in the entrance lobby and rotunda and adjacent rooms on the first floor.

Among many things provided in the way of entertainment, the supply men, through the Water Works Manufacturers' Association, extended an invitation to all members and guests to take a 16-mile trolley trip to and along Lake Ontario early one evening, where a fish dinner was served at Manitou Beach. On the return trip to the city a stop was made at Ontario Beach Park, described on the program as the "Coney Island of Rochester." As guests of the city, the members and visitors had an opportunity to listen to an excellent band concert in the park arena on Thursday evening. Entertainment in other forms by the supply men, the city and the citizens of Rochester was not lacking.

A CAR LIFTING MACHINE, for lifting the bodies of large cars off the trucks, has been in use for some years at the shops of the International Sleeping Car Co., near Ostend, Belgium. It consists of a pair of double-web trusses 59 ft. long and 27½ ins. deep, through each end of which passes a vertical screw 3 ins. diameter, with a square thread 19.64-in. wide. Two of the screws have right-hand and two have a left-hand thread. At the top of each screw is a revolving nut supported by a cross frame on two steel uprights which form guides for the trusses. Rollers ride against these guides. A spur wheel on the nut is driven by gearing, and all the gears are connected so as to work simultaneously. The machine is installed at a repair pit, the rails being supported on pedestals at the floor level, so that the trusses can be lowered beneath the body. For the sleeping cars (which have mainly the same truck spacing), four hinged brackets are swung out to engage with the sill or body bolster; these are locked in place by pins, and I-beams are fitted between them. By operating the screws the car is then raised bodily from its trucks. For other cars, cross girders are placed between the trusses, and blocking fitted between these girders and the car sills. The sleeping cars weigh about 34 tons, of which the body represents 24 tons (to be lifted) and the trucks 10 tons. The body can be raised to the full lift of 32 ins. in five minutes, and the machine works so quickly and easily that it is frequently used for quick repair work, such as replacing an elliptic spring or an axle and pair of wheels. At the same shops, cars are raised by jackscrews and a gang of 16 men. The cost per lift is said to be 2 cts. with the machine and 50 cts. by hand. The outfit of jacks and cross girders cost about $500, while the machine (erected) cost about $1,500. Besides this, the pit gives greater accessibility for repair work. The machine handles about 200 cars per year. It was designed by Mr. A. Berger, now Chief Engineer of the central shops of the Belgian State Railways at Cuesmes, and was built at the railway shops at Malines. It is described by Mr. Berger and Mr. Van Mierlo (Chief Engineer of the Sleeping Car Co.) in the April "Bulletin" of the International Railway Congress.

The Comparative Merits of Steel and Cast-Iron Pipe.*

By ALLEN HAZEN,† M. Am. Soc. C. E.

That which follows relates only to large mains, which I shall define provisionally as mains 36 ins. in diameter and larger. About twenty years ago steel plates became available in large sizes and at comparatively low prices, and these at once largely replaced wrought-iron for such pipes. Pipes made from steel plates had advantages and soon found extended application in the construction of the large water mains that were then demanded in increasing numbers to meet the needs of growing populations and the increased per capita use of water.

From that time to the present the relative merits of cast-iron and steel for large water pipes has been discussed. Much has been said upon both sides. The author will not attempt to enumerate all the arguments that have been used, but only to present the salient features of the case as they present themselves to him, under the conditions that now exist in the northeastern states.

Steel costs more per pound than cast-iron, but it is stronger and in some respects more reliable. A steel pipe ¼-in. thick may be, and often is, stronger than a cast-iron pipe 1 in. thick, and is commonly cheaper. When steel has replaced cast-iron in pipe it has simply done what steel has done in a hundred other directions in buildings, in machinery, and wherever a higher form of metal has advantages more than commensurate with its increased cost.

In the past a comparison of the two materials for large pipe lines has often rested upon a consideration of the relative durabilities, real or supposed, taken in connection with the relative costs. The steel pipe has been assumed to be less durable, because the metal was thinner and would rust through quicker. But it was much cheaper. For instance at Springfield [Mass.] for twelve miles of 42-in. pipe for which competitive bids for steel and cast-iron pipe were obtained in 1908 the relative costs were in the ratio of 2 for steel to 3 for cast-iron. Cast-iron would have cost $600,000. It was actually laid in steel at a cost of $400,000. This ratio probably is not far out of the approximate relative costs of the two materials for large pipes under considerable pressures under the conditions that have ruled in the last few years.

The matter has frequently been presented in this way: the money saved by using steel pipe in a certain case, amounting let us say to one-third of what would be the cost of a cast-iron pipe line, or 50% of the cost of the steel pipe line, if put at interest at prevailing rates would amount to enough to lay a new line of steel pipe at the expiration of some arbitrary period for which it is assumed that the steel pipe will last. The period assumed in making this calculation has seldom been less than 25 years or more than 40 years. In many cases this calculation has been made and the steel pipe has been put in with the belief that it was better business to use it even though it rusted through and ceased to be serviceable at the end of the relatively short period assumed for its life.

Large pipes, as defined in this paper, are most frequently used in the supply pipes of a water-works system, and less frequently in the distribution, and in such supply mains other conditions than the wearing out or loss of strength of the metal commonly limit the useful life of the pipe.

Reduction in pipe capacity and increase in [water] demand limit the time that a given pipe will by itself perform the functions for which it was laid, and when, because of these, it ceases to be able to perform its work another line must be laid to help it out. When this occurs the first line may be considered to have lost a part of its value, and it may then be worth only the difference between what it would cost to lay a new main to supply the whole service and to lay a new main to supply the service in connection with it. This will commonly be only a fraction of first cost. Much of the value is then gone although the pipe may be physically sound.

These practical considerations in most cases limit the full useful life of steel and cast-iron pipe in supply mains of growing cities to periods below the term during which the shell is sound.

The oldest steel pipe lines now in use are about twenty years old. They are still in good condition. Little has been spent upon them for repairs, and there is every prospect that they will continue in useful service for a long time. Curiously, it is some of the more recently laid lines that have given most trouble from deterioration.

The weakness of a well-made steel pipe is its liability to perforation. The experience of the last years has emphasized this, and recognition of a weakness is the first step in correcting it.

Perforations of steel pipe are caused in two ways:

(1) Mechanically. The escape of a small quantity of water through an accidental opening (at a high velocity because the pressure in the pipe is great) results in eddy action on the outside of the pipe which gathers grains of sand and brings them forcibly against the outside of the pipe, and in a comparatively short time cuts the steel and makes a perforation of sufficient size to be an important leak.

The remedy is to test the pipe under more than full pressure before the trench is backfilled, to calk it tight and to make the joints so substantial that there will not be chance for openings to occur.

(2) Chemically. It is a curious property of steel plates that corrosion is not equally distributed, but is concentrated in small places. Once in a while there is a place which for some reason corrodes more rapidly than the rest of the plate, and where finally the steel will be eaten entirely through, making an opening which allows the escape of water. There is clearly some imperfection in the steel plate which allows the corrosion to take place which finally results in perforation, while 99% of the surface of the plate remains entirely free from deep corrosion.

The writer believes that in many cases there is a reason for preferring steel to cast-iron which is more important than the saving in cost, namely, the greater strength and reliability of steel. This greater reliability is due largely to the fact that steel is malleable, and therefore capable of being bent and deformed by settlement in the trench and movements under external forces without breaking or reduction in strength, whereas corresponding forces acting upon cast-iron pipe would break it.

Cast-iron pipe in the past has been commonly designed with a thickness of wall sufficient to resist, at an assumed tensile strength, and with an assumed factor of safety, the internal pressure of the water in the pipe, with a further allowance for water ram, and generally with a further arbitrary addition to the thickness of the walls to cover inequalities in casting.

The actual test and proof of the formulas that have been used in making this calculation is that the pipe designed by them has in general been satisfactory in service, and the percentage of breakage in actual use has been small.

It is to be noted, however, that most of the experience relied upon in reaching this conclusion relates to pipes smaller than 36 ins. in diameter. That relating to large cast-iron pipes, although considerable, is by no means as great.

It now seems that the forces taken into account in the formula are not the only ones that tend to break and that do break cast-iron pipe. In addition, there are internal stresses due to the unequal cooling of the casting; there are stresses that grow out of the fact that the pipe is unequally supported along its length and acts as a beam between points of support, and especially there is the weight of the backfill in the trench carried on the top of the pipe and transmitted through the sides of the pipe to the material underneath. The tendency of this load is to break the pipe.

Prof. Talbot of the University of Illinois has investigated the amount of stress produced by fill on pipes of cast-iron and other materials by embedding them in sand and loading them to the point of destruction, and has recorded amounts of load or fill required to break them under various conditions.

The important matter for us is that the stresses that result from these other forces are cumulative to a considerable extent with those resulting from the internal pressure of the water in the pipe.

In a paper recently presented to the New England Water Works Association I attempted to analyze some of these stresses. I will not repeat at this time what is there printed; it will suffice to say that the stresses resulting from the load of backfill are important in pipes of large sizes and make a difference in the thickness of walls required. In other words, large cast-iron pipe designed by the formulas that have been used are not as strong in proportion as small pipe designed by the same formula.

Practical experience seems to bear this out, for there have been relatively more breaks in large cast-iron water pipes than in small ones. Statistics are not easily obtained of sufficient completeness to be of value, but I think almost any water-works superintendent who has had 48-in. or 60-in. cast-iron pipe in his system, or even 42-in. pipe, will support the proposition that the destructive breakage of such pipe has been greater proportionally than with small pipe.

Further, the possibilities of damage with breaks in the large pipes are greater. It is possible in a few minutes to do thousands of dollars worth of damage by one break in a large pipe in a populous district.

Although steel pipes have been designed with nominal factors of safety no greater than those used for cast-iron pipe, when all the conditions are taken into account the actual factors of safety have been greater. With hundreds of miles of steel pipe in service in the last twenty years, nearly all of it in large sizes, there have been but few recorded breaks, and, so far as the author knows, not a single case of a break of a destructive character; no such record can be shown for cast-iron pipe.

With cast-iron pipe, in case of breakage the side of a pipe blows out, and all the water that the pipe is capable of carrying is discharged until the reservoir is exhausted or the supply shut off. On the oth[er] the few breaks that have occurred with steel p[ipe] resulted in comparatively small openings which [allow] the escape of some water, but not by any means [the] discharging capacity of the pipe.

The perforations of steel pipe that have somet[imes] curred and that have been much talked abou[t in] last years, resulting from the rusting or othe[r] sion of the metal and going entirely through t[he] in some cases, result in a relatively small leak[age] does not interfere with the continued operation [of the] pipe, and which leak can be easily, completely a[nd] manently repaired without shutting the water off.

It is to be noted that such breaks as have o[ccurred] in steel pipes most frequently during laying or[dinary] testing, and less frequently in lines in [regular] service, have occurred, as far as the author kno[ws] ways where plates or lock bars or some other p[art] of steel that was relatively hard. The mild steel [is the] most malleable, and although it has the lowest [tensile] strength it makes the most reliable pipe. If t[here is] breakage or trouble look out for hard steel th[at has] escaped the inspector, or that was near the upp[er limit] of tensile strength allowed under the specification[s]. For the greatest safety use soft steel.

Steel pipe is made at the present time in two pr[incipal] patterns, namely, with double-riveted joints and [with] lock-bar joints. The lock-bar pipe is believed to b[e fully] equivalent in smoothness to cast-iron pipe, and will carry the same amount of water as cast-iron pipe of the same size. Double-riveted pipe, on the other hand, on account of the projecting rivet heads and the other irregularities of joints, has a greater frictional resistance. To obtain the same carrying capacity double-riveted pipe should be 4% greater in diameter than either the lock-bar or cast-iron pipe.

The circular joints of both double-riveted and lock-bar pipe are commonly made in this country by riveting. This makes what is known as continuous riveted pipe. With change in temperature the pipe tends to expand or contract, but is held by the earth and prevented from doing so, and the tendency is converted into stresses which tend to stretch or compress the steel, but which with good design never reach objectionable proportions. As these stresses are in all cases at right angles to those resulting from the pressure of water in the pipe their existence does not affect the strength of the pipe directly, although they may tend to bring out any weak joints and accumulating with other stresses they may have been factors in the production of such few breaks as have been noted with steel pipe.

These temperature stresses must be frankly recognized and provided for at every point. Overlooking them may mean disaster. The details of the joints and connections also must be very carefully studied and must be good.

The design of steel pipe has not been standardized in the same way that cast-iron pipe has been standardized. More skill is required to reach a good and safe design with it. Fortunately the early lines of steel pipe were designed by able men and the precedents then established were good. It is for us to see that they are maintained, and that necessary precautions are not omitted.

Pipe 30 ins. in diameter can be successfully riveted in the field, although the space inside is rather small for good workmanship; 36-in. pipe is more easily riveted, and this marks the ordinary minimum limit of steel pipe as now made.

Generally speaking, with increasing size, cast-iron pipe increases in cost more rapidly than steel pipe. The saving to be made by using steel pipe as compared with cast-iron is relatively small for 36-in. pipe, and would probably disappear with 30-in. pipe under present conditions; it increases rapidly for 48-in. and larger pipe. This is true even with the methods of calculating the thickness of wall of cast-iron pipe that have been used in the past. When Prof. Talbot's work is taken into account, and the increased thickness logically called for is allowed on the larger sizes of cast-iron pipe, the difference will become greater.

There is a limit to the thickness of castings that can be advantageously used. A large pipe with very thick walls is probably relatively less strong and reliable than one with thinner walls because the internal stresses in the thick casting are greater and there is more likelihood of its going to pieces from its own internal stresses, acting either by themselves or in conjunction with other stresses from external sources.

When all these matters are taken into account large cast-iron pipe for considerable pressures will increase in cost almost as rapidly as the square of the diameter of the pipe. In other words, there will be relatively small saving by using very large lines of cast-iron pipe as compared with several lines of smaller diameter.

In our practice in the last years we have seldom considered the use of cast-iron pipe more than 36 ins. and at most 42 ins., in diameter. In nearly all cases we have felt that it was better business to use steel pipe when most capacity was required, or otherwise to divide the line.

Sometimes we have surrounded steel pipe with concrete, thereby adding to its stability and durability. The cost has been increased, but not so as to equal that of cast-iron pipe.

*Abstract of a paper presented to the American Water Works Association, June, 1911.

†Consulting Engineer, 103 Park Ave., New York City.

The Determination of a Reasonable Return for Public Fire Hydrant Service.*

LEONARD METCALF,[1] EMIL KUICHLING[2] and WILLIAM C. HAWLEY,[3] M's. Am. Soc. C. E.

The income of a water-works corporation is usually derived from the performance of two distinct services.: (1) the supply of water for public fire-protection service; (2) the general supply of water for domestic, industrial and public uses. The sum of the receipts from these two sources should be sufficient to place the corporation on a sound financial basis within a few years after the completion of the works, or after about two-thirds of the population of the community have become permanent consumers.

The basis for the determination of the reasonable or legitimate return for public hydrant or fire-protection service has, so far as the writers are aware, never been clearly outlined or passed upon judicially by our courts in such a manner as to be of general applicability.

Not only has intelligent discussion of this subject been neglected, but commercial considerations and offsetting allowances for public franchise, or the right to build and operate water-works, have too often controlled, and have made the actual resulting payments for hydrant rental of little value from a theoretical standpoint; without relation to the cost of the service rendered, and therefore of little significance in a consideration of the cost or value of public fire-protection service.

As is well known to water-works operators, one of the two following considerations has usually controlled in the negotiations leading to the establishment of water-works: (1) what might be termed the "method of averages"—that the hydrant rental and water rates should not exceed the average rates paid in the surrounding district or State, or perhaps in the nearest large city which has found application in the larger communities; and (2) what might be termed the "guaranty basis"—that the hydrant rental should be substantially equal to the interest charges upon the necessary investment, leaving the water rates to meet operating, maintenance and depreciation charges and profit—which has found application in the towns and smaller cities. In the early history of water-works development, therefore, the demand for water service has controlled, rather than any equitable consideration of the cost or value of the service rendered.

This paper outlines a rational mode of determining how much income should be derived yearly from the general public fire-protection service rendered by the works through the public fire hydrants, and does not consider the value of the kindred service rendered by supplying water to special apparatus for extinguishing fire that may be placed in public or private buildings, such as private hydrants or stand-pipes, sprinklers, or other automatic devices. It is assumed that the quantity of water and extra capacity of distributing pipes required for the public hydrant service is always somewhat greater than that which is needed for the special apparatus referred to, when it is brought into action. It has been generally claimed that the yearly cost of this extra capacity for fire protection should be borne by the community as a unit; and when this principle applies, no large additional revenue for special fire-protection service can be expected.

In support of this principle, it is claimed by the makers of special automatic apparatus for extinguishing fire that a discharge of from 750 to 1,000 gals. of water per min. for a period of 10 to 15 minutes has been found by long experience sufficient to overcome most incipient fires in mercantile and factory buildings, whereas from two to ten times this rate of discharge is usually required to extinguish a fire in such a building after it has got beyond the control of the special apparatus and requires the attention of the public fire department. It may also be said that the capacity for fire-hydrant service in even the smallest industrial community should not be less than 1,200 gals. per min., and should increase in some ratio with the population.

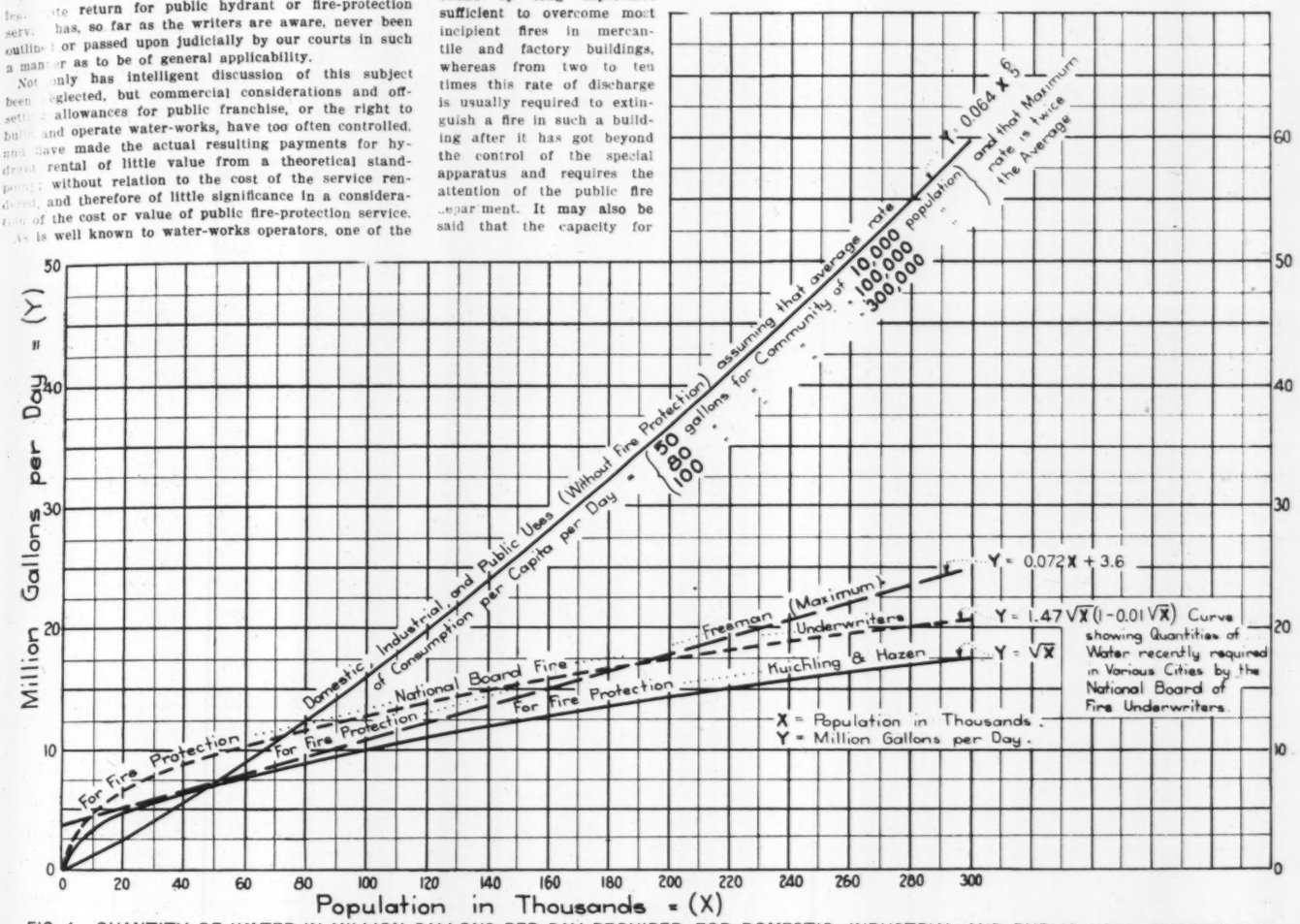
Million Gallons per Day = (Y)
Population in Thousands = (X)
Domestic, Industrial, and Public Uses (Without Fire Protection) assuming that average rate of Consumption per Capita per Day = 50 / 80 / 100 gallons for Community of 10,000 / 100,000 / 300,000 population
Y = 0.064 X^0.9 and that Maximum rate is twice the Average
Y = 0.072 X + 3.6
Y = 1.47 √X (1 - 0.01 √X)
Y = √X
Freeman (Maximum)
Underwriters
Kuichling & Hazen
National Board Fire Underwriters
For Fire Protection
For Fire Protection
For Fire Protection
Curve showing Quantities of Water recently required in Various Cities by the National Board of Fire Underwriters.
X = Population in Thousands.
Y = Million Gallons per Day.

FIG. 1. QUANTITY OF WATER IN MILLION GALLONS PER DAY REQUIRED FOR DOMESTIC, INDUSTRIAL AND PUBLIC USES (EXCEPT FIRE PROTECTION) AND FOR FIRE PROTECTION ONLY.

A grouping of the hydrant rentals, according to localities, gives the following interesting results:[4]

Average of 22 Cities in Eastern States	$29.38
Average of 73 Cities in Central and Southwestern States	45.03
Average of 24 Cities in Southern States	42.54
Average of 6 Cities in Western States	28.42
Approximate Average of Total Number	$41.05

It is of interest to note that the average of all (103 cities), excepting the Eastern cities, is $43.48, approximately 50% greater than for the Eastern States. It is well to note, however, that the average for the Eastern States is obtained from the record of but 15 cities supplied by private works.

In view of the fact that the revenue derived from public fire-protection service is rarely commensurate with the cost of the service in water-works properties in the United States, it is refreshing to note the frank and fair way in which the Railroad Commission of Wisconsin has approached this problem in rating, as evidenced by certain of its reports.

Thus, in its Report No. U.-52 upon the Ashland Water Co., dated Nov. 1, 1909, it says:

(p. 292) "It requires no demonstration to show that a large part of a water plant in every town where the city is a user, is simply held in readiness for the purpose of fire protection. It may not be called into use very often, yet the investment is there and is held in constant readiness.

"In the Appleton Water-Works case, engineers and experts estimated that the cost of constructing that plant would have been reduced by from 40 to 50% if the plant so constructed had been designed only for domestic use. A large part of the equipment is necessary, whether the plant is to be used only for domestic purposes or for both public and domestic service. Where a plant is actually in operation, and large portions of the equipment are used in common for domestic and public consumption, a separation of the investment shows a larger percentage to be devoted to municipal use than in the above-mentioned estimates. The engineer of the Commission has made a detailed separation of properties devoted to municipal and domestic service, respectively."

[Further citations from this and other Wisconsin reports are omitted.—Ed.]

Common Method of Paying for Fire Protection Service.

The usual method of paying for public fire-protection service is by an annual rental per hydrant, coupled with the requirement in the contract of the water company with the community served that one additional hydrant shall be ordered in the case of extension of the pipe system for every 600 ft., more or less, of such extension.

It is believed that this method of charge is a less equitable one than would be *the payment of a lump sum for public hydrant service, granting to the city the right to attach as many hydrants as it may desire to the water mains of the company, upon the additional payment of the actual cost of such additional hydrants and connections; and making provision for the increase of this annual payment for hydrant service, upon some such basis of payment as pro rata increase in population*

*Condensed from a paper presented before the American Water Works Association, at Rochester, N. Y., June, 1911.

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[4]Based on data in a pamphlet upon "Tabulation of Water Rates of Various Cities of the United States, also Data Regarding Fire Hydrants," compiled for the Indianapolis Water Co., August, 1909, by Messrs. Frank C. Jordan, Secretary, and Charles C. Crey, Purchasing Agent of this company, with additions by the writers of population data based upon the U. S. Census returns. See Vol. 24, No. 4, Dec., 1910, Journal of the New England Water Works Association.

or assessed valuation or pipe-line mileage within the municipality or district served by the water-works.

In this connection, it is interesting to note the standard recently adopted by a water company supplying a number of different municipalities which was as follows:

Annual Charge for Fire-protection Service.

Period of Contract.	Per mile of distribution pipe system.	Per fire hydrant in service.
1 year.	$325	$15
10 "	275	6
20 "	260	5

It will be noted that in this case the charge for fire-protection service is a combination of a mileage charge and an annual charge per hydrant, the latter being designed to cover the approximate maintenance and fixed charges resulting from the installation of additional hydrants.

Basis for Analysis of Hydrant Rental Charge.

Obviously, the equitable hydrant rental should lie at some point between the cost of the service to the water company and its value to the community. The value of the public fire-protection service must be greater than its cost, otherwise there will be no demand for it and no hydrant rental question.

The reasonableness of the charge for hydrant rental may be reviewed from five points of view.

(1) The cost of furnishing fire-protection service.
(2) The value of this service to the community, as measured by the saving in fire-insurance premiums, ignoring the effect of the economic waste resulting from loss in business, income and wages, in the reconstruction period following the fire, and the loss of property that cannot be replaced.
(3) The actual and desirable number of hydrants and distance between them and the annual rental per hydrant resulting from the assumption of certain gross annual payments for fire-protection service.
(4) The effect upon taxes, based upon the assessed valuation of property in the municipality or district served, and different assumed annual charges for fire-protection service.
(5) The relative cost of different kinds of public service—police and public safety, light, and fire protection—in the community served.

COST OF FURNISHING FIRE-PROTECTION SERVICE.—It has been assumed, perhaps generally, by engineers, that of the entire cost of water-works that furnish public fire protection, as well as domestic and industrial service, approximately one-half is involved by the cost of the fire-protection service. While this may be the case in large towns or small cities, it is not believed by the writers to be a safe or true statement as applied to the water-works generally, regardless of the extent of population in the communities served.

It is believed that a fairer statement of the true conditions would be to say that *the cost of the portion of the water-works plant involved by fire-protection service probably constitutes from 60% to 80% of the entire cost of the physical property in the case of communities having less than 5,000 population, 20% to 30% in communities of 100,000 population, more or less, and perhaps 10% to 20% in the case of our largest cities.* Whatever the exact figures corresponding to average conditions in the United States may prove to be hereafter, when all of the facts have been determined, if such a time shall ever come, it is safe to say that the figures cited above probably indicate the general conditions very much more closely than do the prevailing opinions as first cited.

As evidence bearing upon the cost of public fire-protection service, the following analysis is submitted:

PER CENT. OF TOTAL CARRYING CAPACITY OF WATER-PIPING SYSTEM, CHARGEABLE TO FIRE-PROTECTION-SERVICE.—From time to time during the past twenty years, standards for the amount of water required for fire-protection service have been suggested by different engineers.

Upon Fig. 1 is shown the quantity of water, in million gallons per day, required for domestic, industrial and public uses, excluding fire-protection demands, and the quantity of water required for fire protection only, under the standards suggested by Mr. John R. Freeman (1892), Mr. Allen Hazen, Mr. Emil Kuichling (1897) and the National Board of Fire Underwriters (1910), as interpreted by the writers.

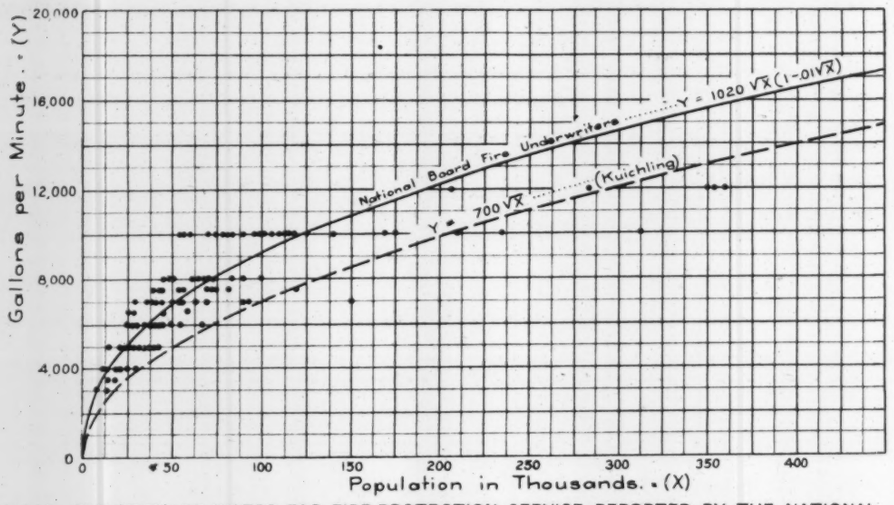

FIG. 2. QUANTITY OF WATER FOR FIRE-PROTECTION SERVICE REPORTED BY THE NATIONAL BOARD OF FIRE UNDERWRITERS (1905 to 1911) AS NECESSARY FOR THE CONGESTED VALUE DISTRICT* OF VARIOUS CITIES, TOGETHER WITH THE RESULTING AVERAGE CURVE† AND THE KUICHLING STANDARD (1897).

*Or main feeders in a limited number of cases. †Prepared by the authors.

Mr. Freeman suggested two standards—a maximum and a minimum—the first of which only is shown on this diagram, for the sake of simplicity and as being the more important to-day. A full discussion of Freeman's standard will be found in the Journal of the New England Water-Works Association for the year 1892, Vol. VII., page 49. The formulas for Freeman's curves, as worked out by Mr. Kuichling, are as follows:

Y minimum $= 1.7\sqrt{X} + 0.03X$ where Y = the number of fire streams.

Y maximum $= \frac{X}{5} + 10$ and X = the number of t... ands of inhabitants.

The Hazen standard, which was based u... Mr. Kuichling's, if we are correctly informed, is t... ound on page 947 of the American Civil Engineers' ... ket-book, recently published:

For average American conditions, take th... root of the population in thousands, and the q... the rate in millions of gallons of water per ... which water should be provided for fire servic...

Mr. Hazen suggests that the required capacit... the pipe system be found by adding to the fire-p... ion service demands, as figured above, the average ... rate of consumption, increased by an allowan... gals. per capita to cover ordinary fluctuations ... ff, or if these fluctuations are unusually great, as ... as 30 to 40 gals. per capita.

From study of this subject some years ag... Mr. Kuichling concluded[5] that the number of effici... fire streams required in our American towns and ... ties might be expressed by the formula:

(1) $y = 2.8\sqrt{X}$, where y = the necessary num... of such streams, and X = the number of thousand of ... pulation.

If we assume that each such stream shall d... arge about 250 gals. per min., the resulting delivery from the fire hydrants will be at the rate of:

(2) $700\sqrt{X}$ gals. per min., or

(3) $\sqrt{X}$ million gals. per day.

This discharging capacity is regarded as sufficient except in case of general conflagration, when help is required from neighboring communities and natural bodies of water in the vicinity are drawn upon by the additional steam fire engines.

If we assume that the average daily consumption per capita for domestic, industrial and public purposes (exclusive of fire-protection service) increases with the population from 50 gals., for communities having a population of 10,000, to 80 gals. for 100,000, and 100 gals. for 300,000, the variation may be expressed approximately by the relation:

(4) $z = 32\sqrt[5]{X}$, where z = the *average* per capita consumption in gallons per day.

This will make the maximum draft from the distributing system for domestic, industrial and public uses (other than for fire hydrants) at the rate of

(5) $44.4X^{4/5}$ gals. per min., or

(6) $0.064X^{4/5}$ million gallons per day, when the maximum rate is assumed to be *twice* the average, and

(7) $0.048X^{4/5}$ million gallons per day, when the maximum rate is assumed to be 1½ *times* the average.

Therefore the *maximum draft*, for combined fire-

[5] "The Financial Management of Water-Works," Trans. Am. Soc. C. E., Vol. XXXVIII., p. 15.

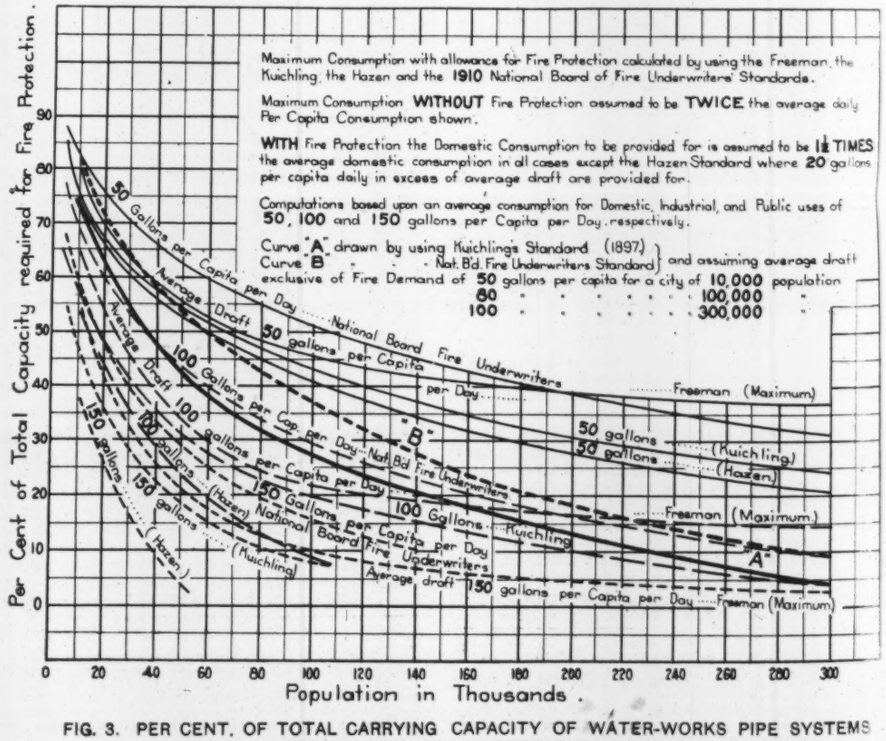
Per Cent of Total Capacity required for Fire Protection.
Maximum Consumption with allowance for Fire Protection calculated by using the Freeman, the Kuichling, the Hazen and the 1910 National Board of Fire Underwriters' Standards.
Maximum Consumption WITHOUT Fire Protection assumed to be TWICE the average daily Per Capita Consumption shown.
WITH Fire Protection the Domestic Consumption to be provided for is assumed to be 1½ TIMES the average domestic consumption in all cases except the Hazen Standard where 20 gallons per capita daily in excess of average draft are provided for.
Computations based upon an average consumption for Domestic, Industrial, and Public uses of 50, 100 and 150 gallons per Capita per Day, respectively.
Curve "A" drawn by using Kuichling's Standard (1897)
Curve "B" - - - Nat. Bd. Fire Underwriters Standard
and assuming average draft exclusive of Fire Demand of 50 gallons per capita for a city of 10,000 population
80 " " " " " 100,000 "
100 " " " " " 300,000 "
Average Draft 50 Gallons per Capita per Day
Average Draft 100 Gallons per Cap per Day
Average Draft 150 Gallons per Capita per Day
National Board Fire Underwriters
Freeman (Maximum)
(Kuichling)
(Hazen)
Nat. Bd. Fire Underwriters
Average draft 150 gallons per Capita per Day
0
10
20
30
40
50
60
70
80
90
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
Population in Thousands.

FIG. 3. PER CENT. OF TOTAL CARRYING CAPACITY OF WATER-WORKS PIPE SYSTEMS REQUIRED FOR FIRE PROTECTION.

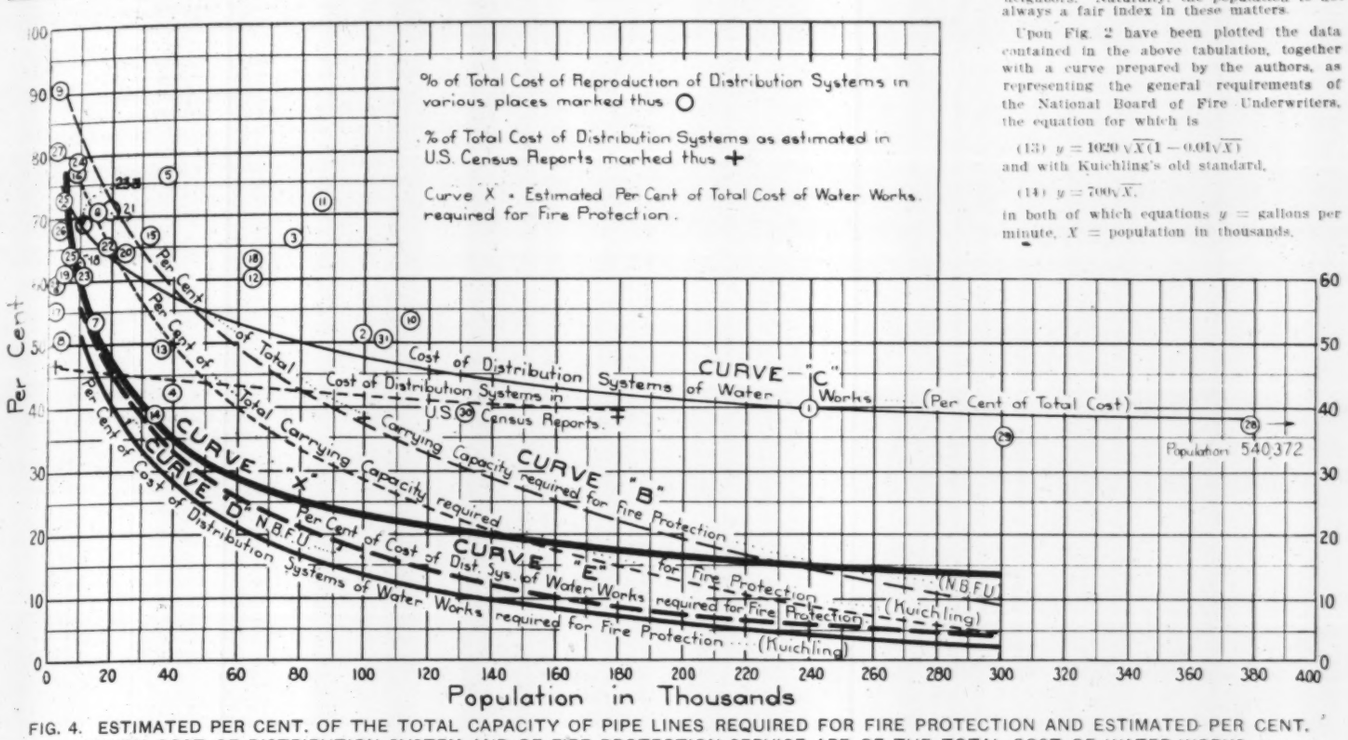
% of Total Cost of Reproduction of Distribution Systems in various places marked thus ○
% of Total Cost of Distribution Systems as estimated in U.S. Census Reports marked thus +
Curve X = Estimated Per Cent of Total Cost of Water Works required for Fire Protection.
Per Cent
Per Cent of Total Cost of Distribution Systems of Water Works (Per Cent of Total Cost)
Cost of Distribution Systems in U.S. Census Reports.
CURVE "C"
CURVE "B"
CURVE "X"
CURVE "D" N.B.F.U.
CURVE "E"
Total Carrying Capacity required for Fire Protection
Per Cent of Cost of Dist. Sys. of Water Works required for Fire Protection (N.B.F.U.)
Per Cent of Cost of Distribution Systems of Water Works required for Fire Protection (Kuichling)
(Kuichling)
Population 540,372
Population in Thousands

FIG. 4. ESTIMATED PER CENT. OF THE TOTAL CAPACITY OF PIPE LINES REQUIRED FOR FIRE PROTECTION AND ESTIMATED PER CENT. WHICH COST OF DISTRIBUTION SYSTEM AND OF FIRE PROTECTION SERVICE ARE OF THE TOTAL COST OF WATER-WORKS.

protection service and domestic, industrial and public uses, is

(8) $\sqrt{X} + 0.064X^{a/s}$ million gallons per day, when maximum domestic rate is *twice* the average, and

(9) $\sqrt{X} + 0.048X^{a/s}$ million gallons per day, when maximum domestic rate is 1½ *times* the average;

and the ratio of the portion of the distribution pipe system devoted to fire-protection service, to the total carrying capacity of the distribution pipe system

$$(10)\quad \frac{\sqrt{X}}{\sqrt{X} + 0.064X^{a/s}}, \text{ and}$$

$$(11)\quad \frac{\sqrt{X}}{\sqrt{X} + 0.048X^{a/s}}, \text{ for the two cases cited.}$$

Again, if it is assumed that *without* fire-hydrant service a distributing pipe system must be designed for a maximum rate of *twice* the average for domestic and industrial uses, whereas *with* fire-hydrant service the maximum rate for domestic and industrial uses may be taken at 1½ *times* the average rate, the ratio of the difference between the required carrying capacities with and without fire-hydrant service to the carrying capacity with such service, becomes

$$(12)\quad \frac{\sqrt{X} + 0.048X^{a/s} - 0.064X^{a/s}}{\sqrt{X} + 0.048X^{a/s}} = \frac{\sqrt{X} - 0.016X^{a/s}}{\sqrt{X} + 0.048X^{a/s}}$$

It will be noted that this ratio reduces to zero when $x = 367.74$, which means that in a city of 367,740 population, the pipe system must be of the same size to provide for a maximum rate of draft of *two* times the average draft for domestic and industrial uses *without* fire hydrant service, as that which would be required by a maximum draft of 1½ *times* the average draft for domestic and industrial uses *with* fire-hydrant service.

It is also possible to determine the ratio $\frac{D}{d}$ of the diameters of two supply mains, one of which (D) is adapted to carrying the combined fire, and domestic and industrial supply, while the other (d) is capable of delivering only the domestic and industrial supply, both pipes having the same hydraulic gradient. Under a given grade the pipe discharge varies as the five halves power of the diameter. If the cost of the pipe per linear foot is expressed in terms of the diameter, the difference in the cost of the two lines may be computed. For the distributing system, however, the relative and absolute amounts of water required for fire hydrant service on the one hand and for domestic and industrial uses on the other will vary in different parts of the city, and hence a general formula covering the entire system cannot be made, as each principal division of the network of pipes must be considered separately with reference to the particular drafts for fire hydrant and domestic purposes.

The results of the application of these principles to each of the three assumed conditions are given in Tables I. and II.

[The authors here gave a table showing "actual quantities of water in gallons per minute, reported by the National Board of Fire Underwriters as necessary for fire-fighting purposes, in excess of domestic consumption,' " for a large number of cities.—Ed.]

Mr. George W. Booth, Chief Engineer of the Board, adds, in comment upon this list:

In the case of the larger cities, it is considered that the possibility of two simultaneous fires in the congested value district is sufficient to justify provision for them.

Structural conditions and the extent of the high-value district, and of the conflagration hazard as determined by our engineers in the field, has some bearing on the quantities recommended, as well as the fire department strength of the city under consideration and of its neighbors. Naturally, the population is not always a fair index in these matters.

Upon Fig. 2 have been plotted the data contained in the above tabulation, together with a curve prepared by the authors, as representing the general requirements of the National Board of Fire Underwriters, the equation for which is

(13) $y = 1020\sqrt{X}(1 - 0.01\sqrt{X})$

and with Kuichling's old standard,

(14) $y = 708\sqrt{X}$,

in both of which equations y = gallons per minute, X = population in thousands.

In making comparison of the relative capacities required for domestic, industrial and public uses, *excluding* fire-protection service, as compared with the former *including* fire-protection service, the authors of this paper have assumed (1) that under the conditions *excluding* fire-protection service, the pipe system must be designed to have a carrying capacity of *double the average daily rate* of water consumption, in order to meet the ordinary fluctuations in demand; second, that under the conditions *including* fire-protection service, provision must be made for a maximum demand for water for domestic, industrial and public uses of 50% *in excess of the average rate of demand therefor*, and in addition thereto for the requirements of fire-protection service, as determined by the several standards outlined above.

In Fig. 3 is shown the per cent. of carrying capacity of water-works pipe systems required for fire-protection, based upon the standards cited for fire-protection ser-

TABLE I., SHOWING PERCENTAGE OF TOTAL CARRYING CAPACITY OF THE DISTRIBUTION PIPE SYSTEM OF A WATER-WORKS PLANT, WHICH IS REQUIRED BY FURNISHING FIRE-HYDRANT SERVICE.

Derived by a comparison of a system furnishing both domestic service and fire-hydrant service, with one furnishing only domestic service (including in the term "domestic service," industrial and public uses, other than fire-hydrant service). Based upon the Kuichling formula.

Population	10,000	25,000	50,000	100,000	150,000	200,000	250,000	300,000
1. When maximum rate for domestic service is assumed to be 1½ *times* the average daily rate therefor in both plants	80.6%	68.6%	57.4%	45.3%	38.5%	33.8%	30.4%	27.8%
2. When maximum rate for domestic service is assumed to be *twice* the average daily rate therefor in both plants	77.6%	62.2%	50.2%	30.4%	31.9%	27.7%	24.7%	22.4%
3. When maximum rate for domestic service is assumed to be *twice* the average daily rate therefor in the plant furnishing only domestic service, and 1½ *times* the average daily rate therefor in the plant furnishing both domestic and fire-protection service	74.1%	58.1%	43.2%	27.1%	17.9%	11.7%	7.2%	3.7%

The authors have assumed in this paper that the third set of conditions is probably of most general applicability, and have given consideration, in making their final figures, to similar figures based upon the requirements of the National Board of Fire Underwriters.

TABLE II., SHOWING THE RELATIVE DIAMETER OF THE SUPPLY MAIN REQUIRED FOR COMBINED DOMESTIC AND FIRE SERVCE, TO THE DIAMETER OF THE SUPPLY MAIN REQUIRED SOLELY FOR DOMESTIC SERVICE.

Including, in the term "domestic service," industrial and public uses, excluding public hydrant service. Based upon Kuichling formula.

Population	10,000	25,000	50,000	100,000	150,000	200,000	250,000	300,000
1. When maximum rate for domestic service is assumed to be 1½ *times* the average daily rate therefor in both plants	1.927	1.590	1.407	1.273	1.214	1.179	1.153	1.139
2. When maximum rate for domestic service is assumed to be *twice* the average daily rate therefor in both plants	1.762	1.475	1.322	1.214	1.166	1.139	1.120	1.107
3. When maximum rate for domestic service is assumed to be *twice* the average daily rate therefor in the plant furnishing only domestic service, and 1½ *times* the average daily rate therefor in the plant furnishing both domestic and fire-protection service	1.718	1.417	1.274	1.135	1.082	1.051	1.030	1.015

EXAMPLE.—From this table it appears in a city, having a population of 100,000, the ratio of the diameter of the supply main required for combined domestic, industrial and public uses, as well as for fire-hydrant service, to the diameter of the supply main which would serve the former uses only, excluding public fire-hydrant service, is as 1.135 to 1.

The authors have assumed in this paper that the third set of conditions is probably of most general applicability, and have given consideration, in making their final figures, to similar figures based upon the requirements of the National Board of Fire Underwriters.

vice, and three different average daily rates of consumption for domestic, industrial and public uses of water: 50, 100 and 150 gals. per capita daily. Upon this diagram are shown two curves: "A," based upon the Kuichling standard, and "B," based upon the National Board of Fire Underwriters requirements, and both based upon the assumption of a varying per capita consumption for domestic, industrial and public uses of water of 50 gals. per capita daily for a city of 10,000 population; 80 gals. per capita daily for a city of 100,000 population; and 100 gals. per capita daily for a city of 300,000 population.

From curves "A" and "B," it will be seen that upon these assumptions, as to the carrying capacity of the pipe system, there is chargeable to fire-protection service (see Table III.):

TABLE III.—PORTION OF CARRYING CAPACITY OF PIPE SYSTEM, CHARGEABLE TO FIRE PROTECTION SERVICE.

Cities having population of (1)	Per cent. according to Kuichling standard. (2)	Per cent. according to Nat'l Bd. of Fire Underwriters' 1910 standard. (3)
10,000	74%	83%
50,000	43%	54%
100,000	28%	37%
200,000	12%	19%
300,000	4%	9%

While it is believed that the minimum values shown on this curve are too low, particularly under the old Kuichling standard, the curve probably clearly indicates the general tendencies.

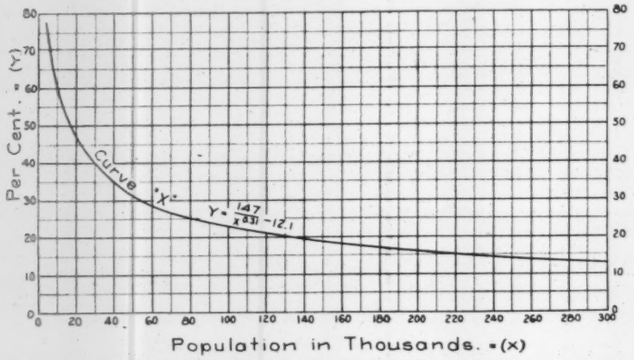

FIG. 5. ESTIMATED PORTION OF THE TOTAL COST OF WATER-WORKS NECESSITATED BY FIRE-PROTECTION REQUIREMENTS.

WATER CONSUMPTION.—As bearing upon the question of water consumption the figures given in Table IV. are of interest. The statistics relating to the United States were worked up from the United States Census Bureau, Department of Commerce and Labor, Report upon "Statistics of Cities Having Population of Less than 30,000 for the Year 1907." The figures for England, France and Germany were worked up from Debauve and Imbeaux's Distributions d'Eau, Paris, 1905.

TABLE IV.—AVERAGE WATER CONSUMPTION IN CITIES OF THE UNITED STATES, ENGLAND, FRANCE AND GERMANY.

Country. (1)	No. of cities. (2)	Range of population. (3)	Consumption in U. S. gals. per capita daily. Max. (4)	Min. (5)	Av. (6)
United States.	13	300,000—4,225,000	344	76	164
United States.	22	100,000— 300,000	230	51	111
United States.	34	50,000— 100,000	301	40	116
United States.	44	30,000— 50,000	398	26	117
United States.	113	30,000—4,225,000	398	26	121
England	37	46,000—6,306,000	83	18	38
France	41	19,000—2,714,000	273	7	54
Germany	38	9,100—1,884,000	66	6	28

As bearing upon the maximum demand for water, as compared with the average daily consumption throughout the year, the following tabulation reprinted from the 32d Annual Report of the State Board of Health of Massachusetts, for the year 1900, is significant. [Lengthy table omitted.—Ed.] It will be seen that the maximum weekly consumption rarely equals double the average weekly consumption for the entire year, while the maximum daily consumption is from two to four times the average daily consumption for the entire year. The minor fluctuations are, however, taken care of by the storage capacity of the reservoirs and the surplus pumping capacity in the case of direct pumping systems. It is believed, therefore, that the assumption made in our comparison, to wit, that with a pipe system designed solely for domestic and industrial uses, the maximum demands should be assumed to be about double the average daily demand, is probably fair, for if the maximum demand should exceed double the average demand, it would at most mean that there would be some fall in the normal pressure under which the water was delivered, and not an actual failure to deliver the required volume of water. In the case of the large community, the ratio would probably be less than double; in other words, the maximum demand would probably be relatively less, as compared with the average demand, than in the smaller community, and this is one reason for modifying curve "A" in the diagram, in its application to the larger communities.

SUBDIVISION OF COST OF THE PHYSICAL PLANT OF WATER-WORKS PROPERTIES.—In Table [omitted] are shown data relating to the subdivision of the reproduction cost of the physical plant of water-works properties, based upon estimates submitted in water-works valuations, which have come within the experience, or under the observation of the authors.

In Table [omitted] are shown similar data kindly furnished to the writers by Mr. John W. Alvord, of Chicago; in Table [omitted] data from Mr. Morris Knowles, of Pittsburg, and in Table [omitted] data based upon the published reports of the Railroad Commission of Wisconsin.

RESULTING ESTIMATE OF COST OF FIRE-PROTECTION SERVICE.—Upon Fig. 4 have been plotted the data given in the tables just mentioned relating to the percentage of the reproduction cost of the physical plant of water-works system, chargeable to the distribution pipe system, and curve "C" indicating the general average conditions; curves "A" and "B," showing the percentage of the total carrying capacity of the pipe distribution system, required for fire-protection service, replotted from Fig. 3; and curves "D" and "E" showing the resulting percentage of total cost of the distribution system of water-works plants, chargeable to fire-protection service, based upon curve "C," and the requirements of the Kuichling and the National Board of Fire Underwriters' standards, respectively. It will be noted that curves "D" and "E" are based *solely upon distribution pipe system costs*, whereas the fire-protection service may involve some slight additional cost in supply and reservoir systems, and substantial increase in cost of pumping capacity. The costs involved by these increased needs will be much more important in small plants than in large plants, except when independent high-pressure fire-protection systems are required.

Curve X, shown by Fig. 5, the equation for which is $y = \frac{147}{x\ 0.31} - 12.1$ in which y = % of total cost x = population in thousands, represents the judgment of the authors as to the approximate percentage of the total cost of water-works involved by the requirements of fire-protection service, taking into consideration not only the distribution pipe system, but also any additional cost involved in the water-supply and reservoir systems, pumping capacity, etc., and the limitations of the assumptions made above as to per capita consumption and fluctuations in rate of water consumption in cities of different sizes. Attention is again called to the fact that these studies are of comparative value only, as indicating general tendencies and that substantial departure from normal conditions, as outlined, is to be anticipated in individual plants, so that if reliable information is desired concerning any particular plant the studies should be based upon the actual conditions existing at that plant. For comparative purposes, however, the curve is suggestive. The data shown by these curves are also given in tabular form in Table V.

TABLE V.—ESTIMATED COST OF PORTION OF WATER-WORKS PLANT CHARGEABLE TO FIRE-PROTECTION SERVICE.

Population. (1)	Cost of distributing pipe system in % of total cost of water-works. "Curve C." (2)	Per cent. of cost of distributing pipe system chargeable to fire-protection service under Kuichling Standard. "Curve D." (3)	Per cent. of cost of distributing pipe system chargeable to fire-protection service under Nat'l Board of Fire Underwriters Standard. "Curve E" (4)	Per cent. of cost of entire plant chargeable to fire-protection service. "Curve X." (5)
5,000	72%	—	—	77%
10,000	68%	50.3%	58.0%	60%
50,000	54%	23.8%	29.0%	32%
100,000	47%	13.1%	17.5%	23%
300,000	39%	1.6%	4.0%	13%

It is evident that the relative cost of the portion of the plant devoted to public fire-protection service is greater in small cities than in large ones, and greater also in purely residental cities than in manufacturing cities.

COST OF INSTALLING EXTRA HYDRANTS.—The cost of installing extra hydrants will vary with the different conditions under which the work has to be prosecuted. Upon the large mains, particularly those in the heart of the city, the connection is likely to be made through the agency of a Smith tapping machine, with interruption of the service, placing a valve upon the hydrant branch. In the city not only will various obstructions be encountered, but the paving of the street will add substantially to the cost of the work. In outlying residental districts, particularly where the hydrants are inserted on small mains, such as 6-in., gates may be omitted from the hydrant branches, little or no pavink may be encountered in the work. The general range of probable costs of cutting in hydrants may perhaps be said to lie between $50 and $150 per hydrant, as follows:

	Diameter of pipe 24-in.	12-in.
Excavation and backfilling....	$8 — $12	$8
Paving	12 — 20	15
Smith's sleeve, valve & box...	62 — 62	31
Labor, lead and yarn.....	8 — 10	5
Hydrant	28 — 32	30
C.-i. pipe 20' 6" and hydrant branch.....	8 — 10	8
Total.....	$126 — $146	$97

*Cutting in special.
†Includes excavation, laying and backfill etc.

Operating Charges Upon Public Fire-Protection Service.

The data relating to the operating and maintenance charges, involved in the fire-protection service, are meager. It is believed that these charges lie between 5 and 10% of the total annual operation and maintenance charges, including taxes but excluding depreciation, interest, and profit allowances.

If we assume the gross income for small works to be 15% per annum of the value of the works, and the portion of the gross income chargeable to hydrant protection service, to be 10%, we should have an annual cost of operation and maintenance, including taxes, in terms of the value of the property, amounting to approximately 1.5%; while for large works we might assume for the corresponding figures 6% × 10% = 0.6%. In other words, the range of operating charges would seem to lie between 1½% and ½% of the value of the property, depending upon the size of the community. While these limits will undoubtedly be exceeded in individual cases, these estimates will perhaps serve for a genral analysis of the problem. The limited amount of data upon which the above figures are predicated, however, must be clearly borne in mind.

For depreciation, interest, and profit allowances we might assume approximately:

Depreciation	1% to 2%
Interest	6% to 6%
Profit	0% to 2%
Total	7% to 10%

or say 8% of the value of the portion of the system involved by fire-protection service.

Need of Inquiring Into Number of Hydrant Nozzles.

Attention is called to the need of inquiring into the number of hydrant nozzles as well as the number of hydrants attached to the distribution pipe system. Point is given to this fact in the excellent tabulation, now unfortunately out of date, made by Mr. Dexter Brackett, Chief Engineer, Metropolitan Water and Sewerage Commission, of the number of hydrants and fire reservoirs in use in different cities, together with the total number of hydrant nozzles and hose connections per mile of pipe in different cities in the United States, (17th Annual Report of the Boston Water Board, January 31, 1893). In this it appears, for instance, that while Chicago had 9.9 hydrants per mile of distribution system, as against 11.5 in Boston, the number of hose connections per mile of pipe was but 19.4 as against 35.8 in Boston.

Value of Fire-Protection Service.

It is exceedingly difficult, if not impossible, to get accurate information concerning the amount of insurance risks carried and premiums paid in any community, from which their relation to the assessed valuation can be determined. It is doubtful if insurance men even have comprehensive figures of this sort, and it may at least be said that the writers have been informed by insurance men that they neither had such data nor knew where they could be obtained. [Tabular and other data on this subject are here given in the original; see "Recapitulation" at end of our abstract.—Ed.]

Actual and Desirable Number of Hydrants.

In Table [omitted] (courtesy of the Indianapolis Water Co.) is shown the approximate number of feet of water pipe per hydrant in different cities in the United States, the average being 555 ft. excluding Indianapolis, or 528 ft. including Indianapolis. The latter corresponds to approximately 9.5 of hydrants per mile of pipe line.

Broadly speaking, it may be said that the tendency at the present time is to reduce the hydrant interval, or increase the number of hydrants per mile, in the interest of decreasing the amount of hose required and correspondingly increasing the efficiency of the fire-protection service.

The limiting of the number of hydrants which may be attached to the mains is, to say the least, unfortunate

except for the fact that increased number of connections with the mains carries with it some additional danger of injury and leakage and some added cost in construction and maintenance. Nevertheless the community should be encouraged to place the hydrants close together rather than far apart—150 to 250 ft. apart in important thickly built-up districts, and 300 to 500 ft. apart in residential districts, with houses well separated; all depending upon the character of the fire risk and values involved. Even if the city is called upon to bear the added expense of the installation, the saving to it in better service and fire hose more than offsets the expense involved.

(2) That hydrant rentals as offsets to taxation or as offsets to water value are considered by the authors as undesirable since there is no economic relation between the one and the other case, and such offsets befog the real issue.

Recapitulation and Conclusions [Condensed].

(1) Public fire hydrant service in the United States is usually paid for upon the basis of an annual rental for each hydrant.

(2) These hydrant rentals rarely bear any relation to the cost or the value of the service rendered.

(3) They have heretofore usually been determined by average prices paid in the State or surrounding district, in the case of the larger communities, and by the requirement of meeting the interest charges upon the plant involvement, in small ones.

(4) The range of hydrant rentals paid in the United States is in general from $100 per hydrant per year to a nominal sum of $10 more or less. The average hydrant rental is probably in the neighborhood of $40. Some detailed records thereof appear in Tables I. and II.

(5) Statistics obtained from 76 American cities supplied by water companies, out of 140 circulars sent, indicate that there has been no substantial decrease in hydrant rentals in the last thirty years, the substantial reductions occurring in only about one-third of the cities from which replies were received. The data upon this subject are, however, not sufficiently complete to make general characterization safe.

(6) Number of hydrants per mile of distribution pipe system and the corresponding average amount of distribution pipe system per hydrant in 63 different cities in the United States:

	No. of hydrants per mile of distribution pipe.	Aver. amount of distribution pipe per hydrant, in ft.
Avg. of 63 United States cities...	9.5	558
Desirable in heart of large cities.	35 to 21	150 to 250
In closely built-up residential sections.....	26 to 18	200 to 300
In residential districts with houses well separated	18 to 9	300 to 600

A better basis for the consideration of the adequacy of the hydrant installation is perhaps to be had in a study of the area to be served by each hydrant in different parts of the city, the general range of values, under the best modern standard of service, being from 1 acre, in the mercantile and manufacturing districts of highest value, to 3 acres, more or less, per hydrant in the well built-up residential districts.

From an insurance point of view, however, the individual districts should be studied with reference to the number of fire streams which can be massed upon them effectively.

(7) The additional cost of installing extra hydrants upon existing mains probably ranges from $50 to $150 per hydrant, the former corresponding to the outlying residential districts with unpaved streets, the latter to conditions existing in the heart of the city where the mains are large.

(8) The cost of a modern steam fire engine of the sizes ordinarily used is $5,000 to $5,500. The cost per year of maintenance of a fire engine company, including the attending hose company, over that of a hose company of corresponding strength, is about $4,000, including operation, maintenance, depreciation, and interest charges. The per capita annual maintenance cost is approximately $1.50 to $2, exclusive of the interest charges.

The fire engines have been found, recently, to deliver, under average conditions in test, approximately 88% of their rated capacity, the range in individual cases being from well over 100% to less than 50% of the rated capacity; but it is probably fair to say that under actual conditions prevailing during a large fire or conflagration, not more than 75% of the above stated working capacity, or two-thirds of the rated capacity, is developed.

(9) The danger from serious conflagrations, such as the Boston, Chicago, Baltimore and San Francisco fires; property and business loss resulting from them, the hazard involved in having so many services of different character, such as domestic and industrial uses; elevators, fire sprinklers, flushing devices, water motors, etc., upon the same main from which the fire hydrants draft their supply, and greater danger of interruption in service for changes in, and repairs upon them; the construction of buildings covering great areas and reaching to great heights, requiring very heavy water pressures; the relatively greater cost of maintaining steam fire engines to do the same work—have led to the introduction of independent high-pressure fire-protection systems in our largest American cities, having one or more independent sources of water-supply readily available at very short notice, in very large quantities and under pressures up to 200 or 300 lbs. per sq. in.

(10) Hydrant rentals, or the demand for public fire-protection service, may well be examined from five points of view [given at greater length, near the beginning.—Ed.]

(11) The cost of the portion of the water-works plant involved by fire-hydrant service probably constitutes from 60 to 80% of the entire cost of the physical property in the case of communities having less than 5,000 population, 20 to 30% in communities of 100,000 population more or less, and 10 to 20% more or less in the case of our largest cities.

The approximate annual cost of fire hydrant service is estimated at $1 per capita, with variations of 40% more or less in different communities, being perhaps from 60 to 75 cts. in our largest cities, $1 in average cities, $1.25 to $1.75 in our small well-served towns and cities.

These per capita costs of fire hydrant service amount to about $55 per hydrant based upon present practice as to number of hydrants per thousand of population (ranging from 11 to 23 in cities of from above 300,000 population to 30,000 population, and per mile of pipe, ranging from 10.6 to 12.1 in cities of the size first stated).

(12) Data as to the value of fire-protection service are very meager. It is believed that a reduction in insurance premiums of from 25 to 50% results with the introduction of a good water-works system, and that the actual saving is much greater, as based upon the returns made by the Insurance Commissioners in the State of Massachusetts. The saving probably ranges from $1.35 to $3, as follows:

With a reduction in insurance rate of	The corresponding saving in insurance premiums per capita annually may be approximately
20%	$1.08
25%	1.35
33⅓%	1.80
50%	2.70

(13) The cost of public fire-protection service is generally much smaller than that of police and public safety, and public lighting service.

(14) The most common method of paying for public fire-hydrant service in the United States seems to be by annual rental per hydrant, coupled with the requirement that one additional hydrant shall be ordered in the case of extension of the pipe system, for every 600 ft., more or less, of such extension.

(15) Improvement is suggested along the following lines. Let it be provided that:

(a) At stated intervals of say ten years or more, the annual cost of hydrant or fire-protection service as then rendered, including in such cost, operation and maintenance charges incurred by the fire-hydrant service, and depreciation, interest and profit allowances upon the value of that portion of the water-works property necessitated by, or chargeable to it, shall be determined. In the latter allowance for the so-called intangible values, should probably be included in many, if not in all cases. This work should be done by an expert, or board of experts in water-works practice, acting in a purely judicial capacity, regardless of the method of appointment.

(b) Additional hydrants may be placed upon the existing water mains, subject to the approval of the water company, or other competent authority, provided an annual rental be paid for each such additional hydrant, which rental will cover the agreed estimated maintenance and depreciation costs, and interest charges involved by the estimated average cost (or varying cost upon a sliding scale covering different conditions, such as size of main, character of excavation, street surface, etc.) of making such installation.

(c) The basic amount paid for hydrant rental be increased annually, to cover extensions of pipe system made during the year (upon which extensions hydrants may be placed at an agreed interval of spacing) pro rata in the relation of the extension to the length of the pipe system at the time of the review of the hydrant rental quesion, or in the ratio of the relative assessed valuations of property as of those dates, or in the ratio of the populations as of those dates, if the latter can be accurately determined, which is not usually the case. If additional hydrants be desired in excess of the agreed number per mile of pipe on extensions, they can be installed upon the basis outlined above in (b).

In this manner, it should be possible to adjust the hydrant rental annually, without serious issue, and the community will more nearly bear its just share of the burden, divided between the public, and private and industrial consumers, than under the present method.

(16) The offsetting of taxes, or franchise, by free or reduced cost of hydrant service, is believed to be undesirable. If the community sees fit to make a charge against franchise or other intangible property, it should be made quite independently of the hydrant rental, or fire-protection service payment. The company, and the city, are both entitled to know just what burden they have to meet, and to be placed in a position to seek legal redress, in case of injustice or inequitable proceedings. The desirability or undesirability of franchise tax is not touched upon herein; that question is not here at issue.

(17) In conclusion, the writers desire to call particular attention to the admirable reports which have been published by the National Board of Fire Underwriters upon the water-works and fire departments of the leading cities of the United States, in which are contained not only many significant and valuable facts, but suggestions of importance to the designer of water-works systems.

Notes From Engineering Schools.

CENTRAL TECHNICAL COLLEGE OF LONDON.—A few alumni held a meeting in New York City May 27 to consider the formation of a New York State section of the Old Students' Association. The purpose would be to promote intercourse among the old students, or alumni, of the college and to establish the local prestige of the school upon a basis commensurate with its standing in the United Kingdom. It is estimated that there are now about 18 persons eligible for membership in the New York section.

All old students of the college residing in or near New York State are requested to communicate with Mr. W. A. Del Mar, Acting Secretary, Room 1,241, 335 Madison Ave., New York City.

AN EARTHQUAKE IN MEXICO early in the morning of June 7 wrecked some buildings in Mexico City and did considerable damage throughout a large area to the south of that place. The number of persons killed is variously estimated at from a few hundred to more than 1,000.

THE PARIS-TURIN AEROPLANE RACE, noted in Engineering News, June 8, has been abandoned unfinished. Four contestants reached Rome, but were unable to complete the final leg of the course. One aviator, Frey, attempted to complete the trip, but when a few miles out of Rome encountered fog and storms and was seriously injured in the wreck of his machine.

At an aviation meet at Johannisthal, Germany, an amateur named Schendel and his mechanic were killed by a fall from a height of 6,650 ft. while attempting to secure an altitude record.

A COMPLICATED COLLISION wrecked four freight trains at midnight of June 6 on the New York, New Haven & Hartford R. R., near Fairfield, Conn. Five trainmen were killed and a number of others injured. An eastbound freight stopped to fix a hot box and was struck by another eastbound freight following. In this collision, one or both of the trains buckled so that some of the cars were projected onto the adjacent westbound track and wrecked a passing westbound train. A second westbound train close behind the first ran into the wreckage. The accident is ascribed to the failure of the engineer of the second eastbound train to observe a signal set against him.

A REDUCTION OF TELEPHONE RATES has been announced by the New England Telephone & Telegraph Co. in addition to the reduction in rates secured by the Massachusetts Highway Commission (see Eng. News, Oct. 20, 1910). These rates apply particularly to subscribers outside the so-called Boston and suburban districts, which were studied by the Commission. For instance, in Springfield, the more important changes are a reduction from $66 to $63 on one-party business lines; a measured-service rate for a minimum of 780 calls in place of 840; flat residence rates of $36 instead of $42 for one-party service; $30 instead of $33 flat for two-party, and $25 for a four-party service in place of the old six-party lines at the same price. It will be seen from this that the six-party line practically disappears from the Massachusetts service. The reductions in rates, it is estimated, will approximate $200,000 per annum, which is to be added to the $350,000 reduction in consequence of the revision for Boston territory.

A new law will go into effect June 29 throughout the State of Maine compelling every telephone company to connect with any other company in immediately adjoining territories. It has not been announced whether the New England Co. will test the constitutionality of the law, but such has been currently reported.

EXTENSIONS TO THE NEW YORK RAPID TRANSIT Subway system with a total estimated cost for construction and equipment of $257,400,000 were recommended on June 13 by a joint committee of the Public Service Commission and the Board of Estimate. It is recommended that contracts be made with both the Interborough Company and the Brooklyn Rapid Transit Co. The latter company would be awarded all the lines crossing the East River bridges with the bridge loop, the Fourth Ave. subway in Brooklyn, and lines in Manhattan from Liberty St. up Broadway and Seventh Ave. to 59th St. and thence across the Queensboro Bridge. A second line would go from Union Square under the East River to the Eastern District in Brooklyn. To the Interborough is offered a line in Manhattan from 42d St. to the Battery via Seventh Ave. and West Broadway; another up Lexington Ave. on the east side, with extensions in the Bronx, the privilege of

building third tracks on the elevated lines and various extensions in Brooklyn and Queens.

Of the total expenditure the city is to contribute $131,200,000, the Interboro, $54,800,000 for construction and $21,000,000 for equipment, and the Brooklyn Rapid Transit, $26,400,000 for construction and $24,000,000 for equipment. The plan is still to be accepted in its details by the railway companies concerned.

PANAMA CANAL WORK DURING MAY, 1911, is summarized by the following figures just reported to the Isthmian Canal Commission: Total excavation, 2,570,592 cu. yds. place measurement in 26 working days (against 2,691,753 in 24 days in April); the average per working day was 98,869 cu. yds. (112,156 in April). The rainfall was very great, 13.78 ins. (4.86 ins. in April). Earth fill placed in dams amounted to 675,484 cu. yds. (655,148 in April). Concrete was placed to the amount of 126,789 cu. yds. (138,923 in April).

THE CONEY-ISLAND PUMPING STATION for high-pressure fire service has been recently subjected to the second severe test in a serious conflagration since its installation in April, 1905. The first such test was in 1907 when Steeplechase Park was destroyed by fire; the second was the Dreamland fire on May 27, 1911, particulars of which have already been given in these columns.

The pumping plant comprises three gas-engine-driven units. The (Nash) engines are of the vertical, three-cylinder, four-cycle type. The cylinder diameter is 13¾ ins. with 16-in. stroke. At 260 r. p. m., each of the three units develops nearly 175 HP., giving a total of 525 HP. for the entire plant. The gas used is ordinary illuminating gas with a calorific value of 490 B. T. U. per cu. ft. The fuel consumption is about 17.4 cu. ft. per B. HP.-hr. The valves of one cylinder in each engine are arranged to permit the use of compressed air for starting. A separate air compressor driven by its own small gas engine is used to maintain the pressure in a battery of storage tanks of capacity sufficient for starting all three engines twice. The whole plant can be started up and put into full operation in about 2½ minutes.

Each engine is directly connected through spur reduction gearing to a triplex, double-acting piston pump. These pumps, built by the Goulds Manufacturing Co., of Seneca Falls, N. Y., have a piston diameter of 12 ins. with 14-in. stroke. The diameter of suction pipes is 12 ins. and of discharge pipes 10 ins. The pumps are run at about 40 r. p. m., giving a capacity of about 1,000 gals. per min. per pumping unit. The total capacity for the plant is thus about 4,800 gals. per min., which is sufficient for 16 to 20 hose streams. Numerous hydrants are distributed over the 65 acres of area protected in such a way that the entire output of the plant can be concentrated upon any one block of buildings. The hydrants have 2½-in. hose connections and are joined to the service mains by 8-in. piping. The pressure at full capacity is 150 lbs. per sq. in. at the pumps and drops to as low as 140 lbs. at hydrants nearly a mile away. City water is used ordinarily but emergency connections are provided with tide water in Coney Island Creek.

Personals.

Mr. L. F. Slaker, Division Superintendent of the Chicago, St. Paul, Minneapolis & Omaha Ry., at St. James, Minn., has resigned to engage in other business. He is succeeded by Mr. B. H. Briggs.

Mr. Willard C. Brinton, Jun. Am. Soc. M. E., formerly with the Westinghouse Electric & Mfg. Co., of Pittsburg, Pa., has been made Assistant Vice-President of the United States Motor Co., New York City.

Mr. E. G. Schmeisser, Assoc. Am. Inst. E. E., formerly Assistant Engineer in the department of electric traction of the Pennsylvania R. R., has been elected Second Vice-President of the Wiener Machinery Co., of New York City.

Mr. E. H. McHenry, M. Am. Soc. C. E., Vice-President in charge of construction and maintenance of the New York, New Haven & Hartford R. R., has also been made Vice-President in charge of the same departments of the Boston & Maine R. R.

Mr. L. H. Byam, M. Am. Soc. C. E., Assistant to the Chief Engineer, Electric Zone Improvements, New York Central & Hudson River R. R., has resigned to become Secretary and Treasurer of the Elliot C. Brown Co., constructing engineers, New York City.

Mr. Geo. F. Samuel, M. Am. Soc. C. E., has been appointed Engineer of Track Elevation for the city of Chicago. He was formerly Assistant City Engineer, and was in charge of the work on the new Southwest tunnel for the water distribution system.

Mr. Joseph V. Woodworth, formerly Superintendent of the Harwood Mfg. Co., Brooklyn, N. Y., and author of several books on metal working, has been appointed Consulting Engineer on sheet metal and die work for the Taft-Pierce Mfg. Co., of Woonsocket, R. I.

Mr. Jerome Cochran, Jun. Am. Soc. C. E., formerly Professor of Civil Engineering at John B. Stetson University, at De Land, Fla., and recently Designing Engineer with the Corrugated Bar Co., St. Louis, Mo., has taken a position with the Trussed Concrete Steel Co., Detroit, Mich.

Mr. William G. Wilkins, M. Am. Soc. C. E., of W. G. Wilkins Co., Engineers and Architects, Pittsburg, Pa., has accepted the appointment of Governor Tener, of Pennsylvania, as a member of Pittsburg's new city Council of Nine, which is organized under the recently adopted commission-plan charter.

Mr. Richard S. Kirby, for a number of years a member of the faculty of Sheffield Scientific School, Yale University, and at present of the firm of J. A. Kirby & Son, of Port Chester, N. Y., has been appointed to the recently established Burton F. Blough Professorship of Civil Engineering at Pennsylvania College, Gettysburg, Pa.

Dr. Albert Sommer, Assoc. Am. Soc. C. E., formerly an instructor at the Technical University of Dresden in Germany, and until recently Consulting Chemist with the Texas Co., in charge of scientific and development work in connection with the manufacture of petroleum products, has accepted a similar position with the Barber Asphalt Paving Co., New York City.

Mr. L. M. Perkins, formerly Engineer of Maintenance-of-Way of the Lines East of Paradise, of the Northern Pacific Ry., at St. Paul, Minn., has been appointed to the same position for the Lines West of Paradise, at Tacoma, Wash., succeeding Mr. A. R. Cook, transferred. Mr. Andrew Gibson has been appointed Engineer of Maintenance-of-Way of the Lines East of Paradise, with headquarters at St. Paul.

Mr. John J. Bernet, General Superintendent of the Lake Shore & Michigan Southern Ry., at Cleveland, Ohio, has been appointed Assistant to Vice-President C. E. Schaff, at Chicago, Ill. Mr. A. S. Ingalls, Assistant General Superintendent of the Eastern lines at Cleveland, Ohio, has been promoted to General Superintendent, and Mr. Frank H. Wilson, Assistant General Superintendent at Chicago, succeeds Mr. Ingalls at Cleveland.

Obituary.

H. W. W. Reynolds, Assistant City Engineer of New Orleans, La., for 17 years, died at his home in that city on June 5. He was 77 years old and a Confederate veteran of the Civil War.

Charles Wurts Sparhawk, a mining engineer of the firm of John & C. W. Sparhawk, Philadelphia, Pa., died on June 9. He was born in Philadelphia on Aug. 24, 1849, and educated at the Central High School in that city.

Morris Landa Abrahams, Jun. Am. Soc. M. E., Chief Inspector in the office of the Inspecting Engineer, Isthmian Canal Commission, Washington, D. C., died in San Antonio, Tex., on May 28. He was educated at the Hogsett Military Academy, Dansville, Ky., the Agricultural and Mechanical College of Texas and Cornell University, where he graduated in Mechanical Engineering in 1906. He was 26 years old.

Dr. Edward B. Voorhees, Professor of Agriculture at Rutgers College, New Brunswick, N. J., died at his home at College Farm from a stroke of paralysis on June 7. He was born in New Brunswick on March 6, 1865, graduated from Rutgers in 1885 and had been continuously connected with that college and the New Jersey Agricultural Experiment Station ever since. He was a member of the American Chemical Society, the American Electrochemical Society and the Society of Chemical Industry.

Linton B. Sutton, Assistant Consulting Engineer of the Guggenheim Exploration Co., New York City, died in that city on June 11 from anaemia. He was 44 years old and a graduate of the Michigan College of Mines in the class of 1890. After holding various positions in mining work in this country he became associated with the engineering staff of Messrs. S. Neumann & Co., London, England. Later he was Consulting Engineer for the East Rand Proprietary Mines, East Rand, Transvaal. For the past few years he had been with Guggenheim interests in this country and was prominently connected with the work of developing the Nevada Consolidated Copper Mines and and the Bonanza Mine in the Copper River Valley, Alaska.

Rear-Admiral Edward D. Robie, U. S. N., retired, died at his home in Washington, D. C., on June 7. He was born in Burlington, Vt., on Sept. 11, 1831. He entered the Navy in February, 1852 as Assistant Engineer. From 1852-1855 he was with Commodore Perry in his expedition to Japan. He directed the construction and operation of the first electric telegraph line in the Island of Japan, and instructed the Japanese in building and operating their first railway. He took the first daguerreotypes ever made in Japan. Later he was employed in the laying of the first Atlantic cable, from Ireland to America. In 1861 he was a member of the board which designed the first iron floating dry-dock of the United States Navy. During the whole of the Civil War he saw active service; as Chief Engineer of the U. S. S. Mohican" he was present at the capture of Port Royal, S. C., in 1861; later he became Fleet Engineer of the combined fleets assembled at Key West, Fla. After the close of the war he served as senior engineering member of the "Goldsborough Board" to decide on the condition of naval vessels on the Atlantic coast. From 1874 to 1887 he was successively Chief Engineer of the Norfolk Navy Yard, the Boston Navy Yard and the New York Navy Yard. He was retired in 1893 with the rank of Commodore, and in 1906 was advanced by special act of Congress to the rank of Rear-Admiral, for his creditable record in the Civil War. He was a Past-President of the American Society of Naval Engineers, a member of the Loyal Legion and served as a guard of honor at the funeral of President Lincoln in New York in 1865. Of the 191 officers who served with Commodore Perry but three were alive in October, 1909.

Engineering Societies.

COMING MEETINGS.

PACIFIC NORTHWEST SOCIETY OF ENGINEERS.
June 19-23. Annual convention at Seattle, Wash. Secy., Joseph Jacobs, 803 Central Bldg., Seattle, Wash.

AMERICAN SOCIETY OF CIVIL ENGINEERS.
June 13-16. Annual convention at Chattanooga, Tenn. Secy., Charles W. Hunt, 220 West 57th St., New York City.

AMERICAN RAILWAY MASTER MECHANICS' ASSOCIATION.
June 14-16. Annual convention at Atlantic City, N. J. Secy., Jos. W. Taylor, 390 Old Colony Bldg. Chicago, Ill.

MASTER CAR BUILDERS' ASSOCIATION.
June 19-21. Annual convention at Atlantic City, N. J. Secy., Jos. W. Taylor, 390 Old Colony Bldg., Chicago, Ill.

ASSOCIATION OF RAILWAY TELEGRAPH SUPERINTENDENTS.
June 19-23. Annual convention at Boston, Mass. Secy., P. W. Drew, M., St. P. & S. S. M. Ry., Chicago, Ill.

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS.
June 21-24. Semi-annual meeting at Chicago, Ill. Secy., J. C. Olsen, Polytechnic Institute, Brooklyn, N. Y.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.
June 26-30. Annual convention at Chicago, Ill. Secy., Ralph W. Pope, 33 West 39th St., New York City.

SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION.
June 27-29. Annual meeting at Pittsburg, Pa. Secy., H. H. Norris, Cornell University, Ithaca, N. Y.

AMERICAN SOCIETY FOR TESTING MATERIALS.
June 27-July 1. Annual meeting at Atlantic City, N. J. Secy., Edgar Marburg, University of Pennsylvania, Philadelphia, Pa.

AMERICAN CHEMICAL SOCIETY.
June 28-July 1. Annual convention at Indianapolis, Ind. Secy., Charles L. Parsons, Durham, N. C.

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS.
July 6-8. Semi-annual meeting at Chicago, Ill. Secy., W. W. Macon, 29 West 39th St., New York City.

OHIO ELECTRIC LIGHT ASSOCIATION.
July 25-28. Annual convention at Cedar Point, Ohio. Secy., D. L. Gaskill, Greenville, Ohio.

TRAVELING ENGINEERS' ASSOCIATION.
Aug. 29-Sept. 1. Annual convention at Chicago, Ill. Secy., W. O. Thompson, N. Y. C. Car Shops, East Buffalo, N. Y.

AMERICAN METALLURGICAL SOCIETY.—This society was organized at a meeting held April 12 in San Francisco, Cal. It is intended to be a co-operative organization for the expression and development of Western ideas of mining and metallurgy. The object of the society is announced as follows in its by-laws:

The objects of this society shall be two-fold: First, it shall work for the advancement of the arts of mining and metallurgy, employing for that purpose the various means at its command, and more particularly by encouraging the exchange of ideas on mining and metallurgical topics through the medium of professional papers and discussions which shall be given publicity in the transactions of the society; and second,

It shall work for the welfare of its members and shall encourage in them a healthful spirit of mutual cooperation.

The second object appears to cover a department the purpose of which will be to obtain appointments for members seeking employment or changes of position. In spite of its name, which was so chosen to avoid confusion with those of other existing organizations, the society is intended to devote fully as much attention to mining as metallurgy. Provision has been made for establishing chapters in various places.

Membership is open to "any person interested in the objects of the society," but all applications must be passed upon by a committee on membership. The yearly dues are $3.00, in addition to which there is an entrance fee of $3.00 for all new members.

Officers have been elected for the ensuing year as follows: President, Ernest A. Hersam, College of Mines, University of California; Vice-President, Geo. M. White; Treasurer, R. K. Blair; Secretary, R. Stuart Browne, 62 Fremont St., San Francisco, Cal.; Directors, John H. Eggers, Jr., B. W. Begeer and Carlos P. Griffin.